

2019

Le Passage - Towards the Concept of a New Knowledge Instrument

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<http://hdl.handle.net/10026.1/14745>

<http://dx.doi.org/10.24382/478>

University of Plymouth

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UNIVERSITY OF
PLYMOUTH

Le Passage

Towards the Concept of a New Knowledge Instrument

(Epistemological Experiences inside Immersive Dome Environments)

by

Isabella Marzena Beyer

A thesis submitted to the University of Plymouth
in partial fulfilment for the degree of

DOCTOR OF PHILOSOPHY

School of Art, Design and Architecture

April 2019

To my parents

Lucyna and Sławomir Buczek

Acknowledgement

First, I would like to thank all of the wonderful colleagues and friends who believed in me and this dissertation. I am very thankful for all the support, discussions, and exchanges that have aided me throughout my creation and research work, and especially during recent years, leading ultimately to this PhD thesis.

I am grateful to my husband and my son, who followed this process and endowed me with the necessary time needed to finish the writing process. I am especially thankful for the long discussions I had with my father, who had the patience to listen and discuss every aspect of my work in a very delightful manner. I am also thankful to my mother and my husband for their ongoing encouragement.

I am deeply grateful to both my director of studies, Mike Phillips, and secondary supervisor, Roy Ascott, who is also the founder of the Planetary Collegium at Plymouth University. I also thank my third supervisor Jane Grant for pointing me towards important concepts that became relevant to my dissertation. I am grateful to all my supervisors for creating such a wonderful group of people, enabling wisdom, sparkling opportunities for interconnectedness, and creating multiple spaces for knowledge and artistic exchange around the world.

In particular I want to thank my fellow PhD colleagues, who made this process so delightful: Aleksandar Cetkovic for his discussions and exchange on architectural peripheral vision and human models; Julieta Aguilera for her enthusiasm and inspiration regarding VR; Ellen Sebring for her insights on history and historical photographs; Luis Miguel Girao for his inspirational talks about the collaboration between arts and sciences; Nasim Zamanzadeh for her Persian perspective on the concept of empty space; and Blanka Domagalska for her inspiration regarding liminal space. I am grateful to my former PhD fellows, who elaborated the dome field from their perspectives before me. Their work was very inspirational to me, especially in the early stages of this project: Donna Cox, for her work on visual metaphors; and David McConville, for his transcalar performative artworks and brilliant publications.

Most importantly, I am thankful to my first home institution, production office, and all the wonderful people that surround it: the Mediendom in Kiel at the University of Applied Sciences, and further production plants in Melbourne and Warsaw. I am especially indebted to my dear friend and director Eduard Thomas as well as other colleagues, such as Felix Lühning, Bartosz Dabrowski, and Patrick Rupert-Kruse for their support and involvement. I am thankful to my friend Evelin Tihonova for her ongoing motivation throuout, and to Mrs. Schoneboom, who helped me with the administrative process in getting this PhD started. I thank the worldwide planetarium community, colleagues, and friends with whom I exchanged thoughts and visionary ideas from 2005 onwards on many conferences, such as the International Planetarium Society (IPS) and fulldome festivals, and who all share the same love for the arts and sciences in

the 360° coordinate space of the cupola, such as Dan Neafus, Dr. Ka Chun Yu, Carter Emmart, Paul Mowbray and Torvald Hessel.

Finally, my thanks go to my wonderful copy editing office, who have accompanied me and my work through recent years and helped me to bring it to fruition.

Author's Declaration

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award without prior agreement of the Doctoral College Quality Sub-Committee.

Work submitted for this research degree at the University of Plymouth has not formed part of any other degree either at the University of Plymouth or at another establishment.

This study was financed with the aid of a studentship from the Professorinnenprogramm (women professors programme) of the German Federal Ministry of Education and Research and carried out in collaboration with the University of Applied Sciences Kiel in Germany.

A program of advanced study was undertaken in collaboration with the Planetary Collegium, which included nine in-person sessions lasting 10 days, each over a period of three years. Relevant scientific seminars and conferences were regularly attended, at which work was often presented. Additionally, external institutions were visited for consultation purposes, and several papers prepared for publication as well as creative work and film productions. Further information can be found in the Filmography in Appendix II: Creative and Performing Work.

The following external institutions were visited for consultation purposes:

- _Christian-Albrecht University, Kiel
- _Fraunhofer First, Berlin
- _European Space Agency (ESA), Darmstadt, Germany
- _EISCAT Scientific Association, Ramfjordbotn, Norway
- _University of the Aegean, Greece
- _Czech Academy of Sciences, Prague, Czech Republic
- _Shanghai Institute of Visual Studies, Fudan University (SIVA), Shanghai,
- _China Institute for Immersive Media, University of Applied Sciences Kiel, Germany
- _Mediendom at the University of Applied Sciences Kiel, Germany
- _Gates Planetarium at the Denver Museum of Nature & Science, Denver, USA
- _Louisiana Art & Science Museum and the Irene W Pennington Planetarium, Baton Rouge, USA
- _Zeiss-Planetarium Jena, Germany
- _Planetarium Hamburg, Germany
- _Visualisierungscenter C Norrköping, Sweden
- _Copernicus Science Centre, Warsaw, Poland

Publications:

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(ED) Jahrbuch immersiver Medien, Die mediatisierte Gesellschaft: Leben und
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Edge of the Universe“ in Planetarian (magazine)

_Buczek, I. (2010), „Making of | ESA Planetarium“. Article in Digital Production (magazine)

Presentations at conferences:

_Beyer, I. (2015), „The 360°-Creation Process in the Transition of Time“, presentation at i-DAT, Plymouth University, UK.

_Beyer, I. (2015), „The Zoom Transition“ presentation at the Imersa Conference, Denver Planetarium, Denver, USA.

_Buczek, I. (2013), “The Art of Understanding in the Mirror of new Visualization Technologies“. Presentation at COST Arts & Technologies (CAT) Workshop, European Science Foundation, 25 - 27 November 2013, Zagreb, Croatia.

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_Buczek, I. (2012), “Aesthetic of Immersion in the immersive dome environment (IDE), paper presented at Technoetic Telos: Art, Myth and Media Conference at the Ionian Centre for Arts and Culture, Kefalonia, Greece.

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_Buczek, I. (2011), 'The immersive dome environment (IDE): Old concept in a new light or a new hybrid medium to enhance human cognitive faculty?' Paper presented at the TTTT Media Arts Conference at the Shanghai Institute of Visual Art, Fudan University (SIVA), Shanghai

Further presentations on invitations:

_Buczek, I. (2013), "Science Communication – Why in the Dome?". Presentation

delivered at ECSITE (European Network of Science Centers and Museums)
Conference, 07.06.2013, Gothenburg, Sweden

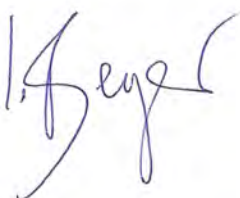
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_Buczek, I. (2011), "Real-Time Systems on the Planetarium Market - Chances
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_Buczek, I. (2011), "Paradigms of the visual speech – emotional and spatial
concepts for the 360° projection medium". Presentation delivered at
Fraunhofer-First, Berlin

Word count of main body of thesis: 79194

Signed: 

Date: April 2019

Abstract

Le Passage

Towards the Concept of a New Knowledge Instrument

Isabella Marzena Beyer

This dissertation is concerned with the analysis and development of the passage concept in immersive dome environments (IDE). The research follows an interdisciplinary approach that draws on practices of scientific and artistic visualisation in the process of knowledge production. The research methodology is informed by my working practice, developing experiences for spherical displays, first inside fulldome planetariums, and currently also inside further 360° media formats such as VR (Virtual Reality), AR (Augmented Reality), and MR (Mixed Reality). The methodology is further underpinned by a media archaeology and interrogated through an ethnographic process of expert conversations and interviews.

The media archaeology part involves the investigation of historical epistemic concepts in science communication in the fields of geography and cosmology used in spherical environments from the 17th century to the present day. The evolvement of the creation process for spherical environments shows how our thinking, understanding, and acting with spatial knowledge have shifted.

The practical element involved is the construction process of passage corridors in science and art in order to generate new knowledge, which I define as passages. The passage concept is further enriched via the lenses of the art of understanding; the diagrammatic; and visuals as knowledge instruments.

The main tool is the IDE, since it has the epistemic potential to create passages through time and scale. In this research the IDE is both an object of investigation, according to its historical classification and its immersive capabilities, and at the same time it is being analysed as an active instrument that produces knowledge and steers artistic language. It can be understood as a model, instrument, environment, and vehicle, being in a transitional state itself—from a historical planetarium environment to a new non-space, allowing for unique and engaging media art forms.

In doing so, the IDE blends scientific frameworks with artistic processes, transforming the newest insights of immersive perception into a new state of the art. The IDE makes this evident through the method of passage and navigation. New future scenarios are presented whilst expanding the passage concept, which can aid our spatial localisation, orientation, and self-constitution, thus shifting our perspective from a sense of place to a sense of planet.

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Prologue

Science and the Three Humiliations of Humanity by Freud

Sigmund Freud wrote at the beginning of the 20th century. During the preceding centuries, humanity had endured from the sciences two great humiliations of their naive self-love, followed by a third (Freud, 1917). The first humiliation came from Nicolaus Copernicus, who proved that the earth—and therefore, humankind—is by no means the centre of the universe, instead being only one of many celestial bodies circulating the sun. The second humiliation came from Charles Darwin, who explained the evolution of species by natural selection and therefore revealed the origin of man to be within the animal world. The third, and according to Freud most significant humiliation, came from the study of psychology, which aims to prove that not even the self is “king of its own castle,” but rather is determined (and restricted) by the unconscious (Freud, 1917, pp. 4–5).

I would like to expand upon this restriction further in the context of perceptual psychology. Human perception is restricted by the capacity of the body’s available senses, namely the eyes, ears, tongue, nose, and touch. For example, the human eye is sensitive to a range of optical information and is said to account for 80% of information input in comparison to the other senses (Ameln & Kramer, 2007). However, micro or macro environments, light spectrums beyond the visible, electromagnetic fields such as bioelectromagnetism

(Malmivuo & Plonsey, 1994), or things that are either too fast, too small, too big, or too slow, lie outside the limits of our perception.

In order to develop our understanding beyond the limits of that which can be directly perceived, human beings have developed different kinds of heuristic instruments, many of which are visual in nature. This is the primary reason why the visual will provide the core themes in this work. Interestingly, human beings sense their environment across the full range of their senses as equidistant from themselves—when turning around and looking above, down, left and right, and around oneself, resulting in a spherical perceptual radius. This might be one of the reasons why spherical displays and tools appear quite natural to us.¹

The spherical encounter can be observed most clearly in a digital planetarium, for example, when the audience is taken from earth on a transitional journey to the outer knowledge sphere of the universe via the NASA's Wilkinson Microwave Anisotropy Probe (WMAP) map (see Figure 1) which has been updated by ESA's Planck satellite mission, which launched in 2009 presenting the cosmic microwave background (CMB) in even greater detail than ever before. The cosmic microwave background (CMB) is leftover radiation from the Big Bang and gives insight into the evolution since the birth of our Universe, nearly 14 billion

¹ Further information on spherical perception will be provided in Chapter 5.

years ago.² For the launch of this mission I had the pleasure to produce the planetarium show Touching the Edge of the Universe.

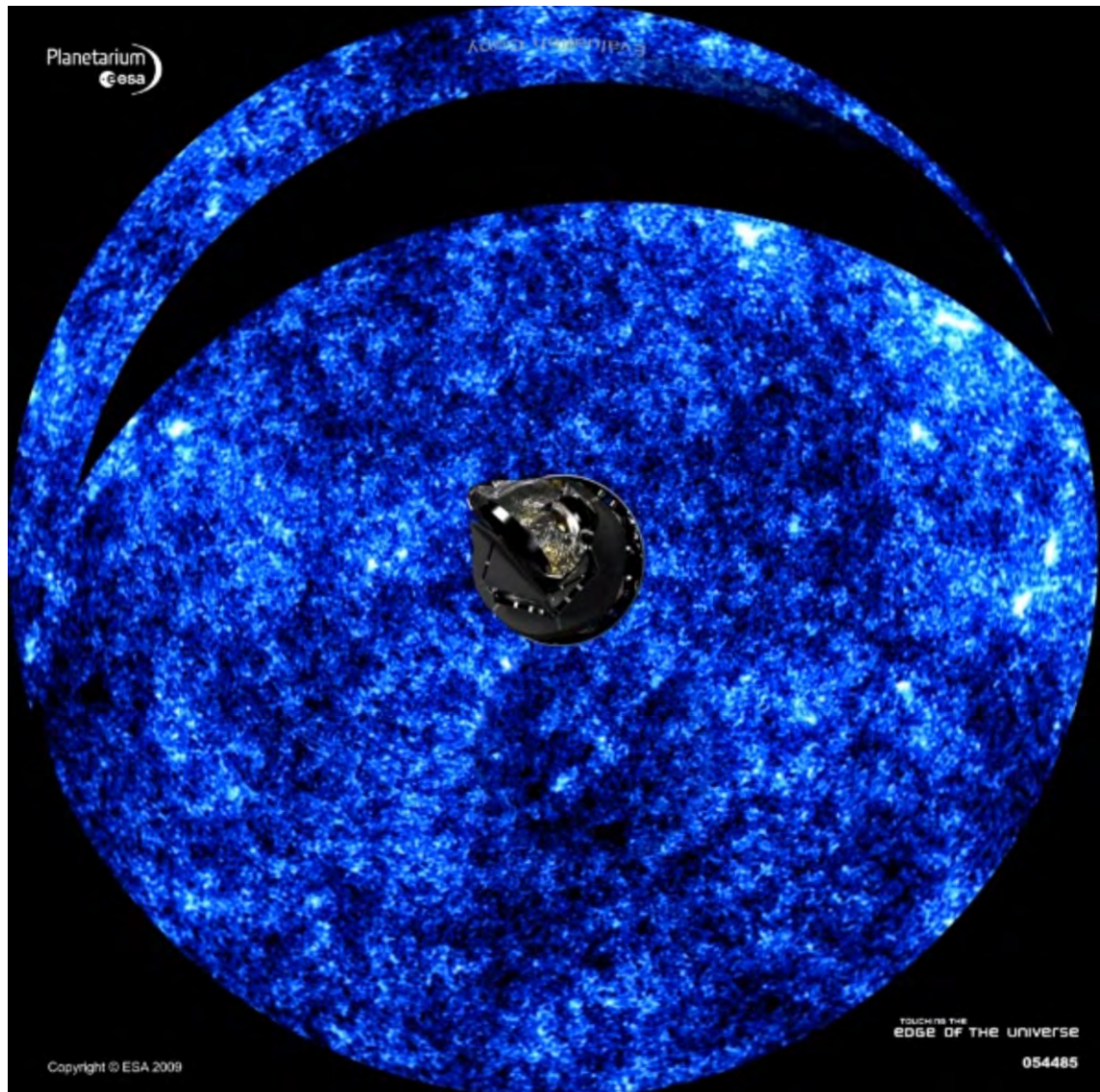


Figure 0.1 Cosmic Microwave Background [CMB] as scanned by Planck. Own work sample from my planetarium show Touching the Edge of the Universe in collaboration with the European Space Agency (ESA) (2009)

When I first started my work at planetariums, I always wondered why our human knowledge horizon is presented as a sphere. How do we know that the universe is spherical, and why would we assume it to have a spherical shape?

² Further information can be seen here:

https://m.esa.int/Our_Activities/Space_Science/Planck/Planck_and_the_cosmic_microwave_background

The whole passage experience, its use and performance via the Digital Universe Atlas (DUA) inside a cupola in real-time, had a profound impact on me, yet raised many questions, such as how important the spherical space is for the experience as well as the interactive component of its real-time nature and the experience of passing as such.

All of the observations we make are based upon the instruments we use. We use them from a single point in the universe—namely, the earth—so, of course, we end up in the same great sphere of knowledge; an analogy to our own, much smaller sphere of perception in our local environment. It is through this sphere of perception that we make our path-view passages whilst travelling, experiencing, and sensing the space both on and around the earth, whether walking, diving, driving a vehicle, being lifted up by an elevator or hot air balloon, or flying in an aircraft. All of these passage moments can be achieved quite naturally inside the Immersive Dome Environment (IDE) through its kinaesthetic effect, whilst using motion inside the spherical display. In these moments the IDE undergoes a visual metamorphosis and transforms into one of these vehicles. The transformation appears so natural that the audience only notices it subconsciously.

Further, these experiences can have a much deeper impact. Moving from one space to another, or from a given scale to another, is central to the experience inside a given virtual space. To encompass this sense of movement, I use the term “passage,” in which the passage functions as a pathway between different scales or as a method to navigate and experience a given space. Therefore, the passage concept occupies a central position in my thesis. The passage is

analysed in its capacity to create a pathway between different scales or as a method of navigation and experience inside a knowledge container. In this context, a knowledge container can be, for example, the Digital Universe Atlas—although other knowledge containers are of course also possible. Please see chapter 2 for more details on the passage concept and chapter 5 regarding the passage creation process.

As a result of my work with the IDE from 2003 onwards, I have come to see the IDE as an instrument with a unique visual heuristic—one, in a very real sense, with the ability to help humankind overcome the three humiliations coined by Freud in order to discover more of the world we live in. The exact form that these heuristics take provides the foundation for my research questions throughout this dissertation.³ All the attributes needed are brought together to structure the overall concept of “Le Passage.” Some of the insights upon which I elaborate with regard to the passage design concept have previously been published in “Le Passage: An Archaeology of Spatial Transitions” (Beyer, 2014).

The following personal encounter I had on a German train illustrates perfectly the immense impact that the IDE can have as a simulation instrument. I was on the ICE—the German high-speed train—traveling from north to south Germany, when I met a very nice, elderly, and well-educated couple. They were medical doctors, and in the course of our conversation they asked me what I do professionally. In an attempt to keep my answer simple and short, I told them I

³ Some of these heuristic attributes are laid out in Chapter 5.

work for planetariums. When they asked whether I was an astrophysicist, I explained that I am a visualisation specialist, projecting images and film material onto the dome's surface, but that I do collaborate closely with astrophysicists. The woman responded by suggesting I was a star and sky creator, which left me slightly speechless. But yes, I said, in a sense I am able to create stars and bring them onto the ceiling of the dome. We can even take you on a journey to the next galaxy! Both looked slightly puzzled at me; if the stars are already there in the night sky, then you are not showing the real stars?

Introduction

Having worked for spherical displays, cupolas, and planetariums in Germany as well as in Australia at the Melbourne Planetarium, and having accomplished fulldome productions from 2003 onwards, I decided in 2010 to start my own academic project in the form of this PhD thesis. This decision was due to my own observations of the reactions to my own work inside the dome. As an artist, designer, or content creator, you basically know every millisecond of your own work. Therefore, during a premiere, I never watch my own content (other than to check it is running correctly), observing the audience and their individual reactions instead. These moments trigger quite an intense mix of emotions, since they reveal how the audience actually reacts to the 360° film that you have

worked on—sometimes for a period of up to two years. The reactions can be quite surprising. For example, a three-dimensional scene consisting of many elements that I worked on for several weeks might be taken for granted, whereas another scene that perhaps only took three days to accomplish could be received with absolute amazement. For my audience, the most thought provoking scenes are those in which the night sky is shown as we normally perceive it from the earth, the viewer being subsequently slowly lifted up whilst also slowly increasing the velocity. As the first star constellations pass by, it becomes evident that the connecting lines are stretched in space due to the varying distances between the stars. Another scene that produced emotional reactions in the audience was seeing the earth in great detail with the blue atmosphere around it. Immediately the audience identified with their living “Spaceship Earth”—our home planet.⁴

Consequently, my first research questions emerged from my working practice—the scenes described above and the strong sense of connection that the presented environments were able to create with the audiences inside the IDE. The mind concepts and knowledge context of the audiences, their capability of identification, and thresholds such as the experience of passing through the star constellations, as well as this particular and all-important sense of place and self-constitution through spatial relocation, were the very first questions that haunted me. It advanced further to questions regarding the immersive

⁴ The concept of “Spaceship Earth” was coined by Buckminster Fuller (1969) and will be further elaborated in Chapter 6.

encounter between epistemic visual and perceptive faculty inside this specific medium. Yet it was not until I learned about the Planetary Collegium that I explored and developed my questions into an interdisciplinary research project in an academic context. In October 2010, I submitted my research proposal. The project commenced with the following primary research questions:

01. Are there historical precedents, models, and approaches that can frame the immersive space as an instrument of knowledge production?
02. What is the epistemological function of immersive space as an instrument of knowledge production?
03. What design mechanisms, methods, and qualities can successfully merge the scientific framework with artistic visualisation?

Whilst working on this dissertation, I completed further fulldome projects that contribute as practical work towards my research—a long journey that I am very happy to finally conclude with this written work. Many aspects and key points will continue to evolve, develop further, and thus remain prominent until they are expressed via an experience, artwork, essay, or publication—perhaps even inside another research project. The most wonderful aspect of, and also the main reason why, I decided to work on this PhD, is that it forms such a fundamental part of one's lifetime experience. Furthermore, it contains numerous concepts and ideas that might hopefully inspire other 360° enthusiasts in their work with this fascinating environment, which I will refer to

throughout the thesis as the Immersive Dome Environment (IDE). This research is thus aimed towards other content producers, artists, designers, and scientific visualisers working in the wondrous and revolutionary field of 360° coordinate space.

Motivation, Aims, and Methods

Since 2003, the IDE has been my laboratory. Throughout this period, I have created over 15 three-dimensional programs for various planetariums and fulldome environments, all of which received a public audience. My creative spaces and production offices have mostly been situated next to exhibition domes, (mainly planetariums) based in Melbourne (Australia), Kiel (Germany), Hamburg (Germany), and Warsaw (Poland). Since October 2010, I have also taught students to develop content for the IDE as well as for further 360° media formats, such as Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR). In September 2017, I was appointed to a professorship for Immersive Media and Transmedia at the University of Applied Sciences Lübeck.

During my work for planetariums, my main interest and focus has always been the visualisation process in science communication and art. Throughout my research work, theoretical and practical knowledge interweaved, often helping me to illuminate specific aspects. My methodology is a careful examination of the 360° visual concept and its diverse applications throughout the centuries as a simulation model, and an active and dynamic instrument in the generation of

knowledge. This exploration is strengthened by media archaeology research and cross-examined through expert conversations and interviews as well as my own practice and case studies in 360°. An interdisciplinary approach was particularly important to me, carefully studying the philosophy of science, media and image sciences, aesthetics, and the psychology of perception—especially regarding visual input and its capability to generate new knowledge.

Especially of interest to me have always been the changing relationship between media and society, and the effects that media have on the individual regarding perception, behaviour, and particularly spatial memory and spatial imagination. Does contemporary media usage strengthen the connection between our body and our spatial environment, or does it weaken this relationship? The German philosopher Dieter Mersch (2011) states that our presence in various digital spaces at the same time leads to a splintered existence and perception. The increasing speed of information exchange causes an even stronger fragmentation of our hectic existence. The usage of virtual navigation devices leads to a fragmented spatial imagination, including many knowledge gaps and a lack of information (Mersch, 2011). Therefore, it will be analysed what experiences the 360° IDE could offer in order to address the undesired fragmentation of our spatial awareness, perception, and presence in the contemporary world.

The Epistemic Status of Scientific Visuals

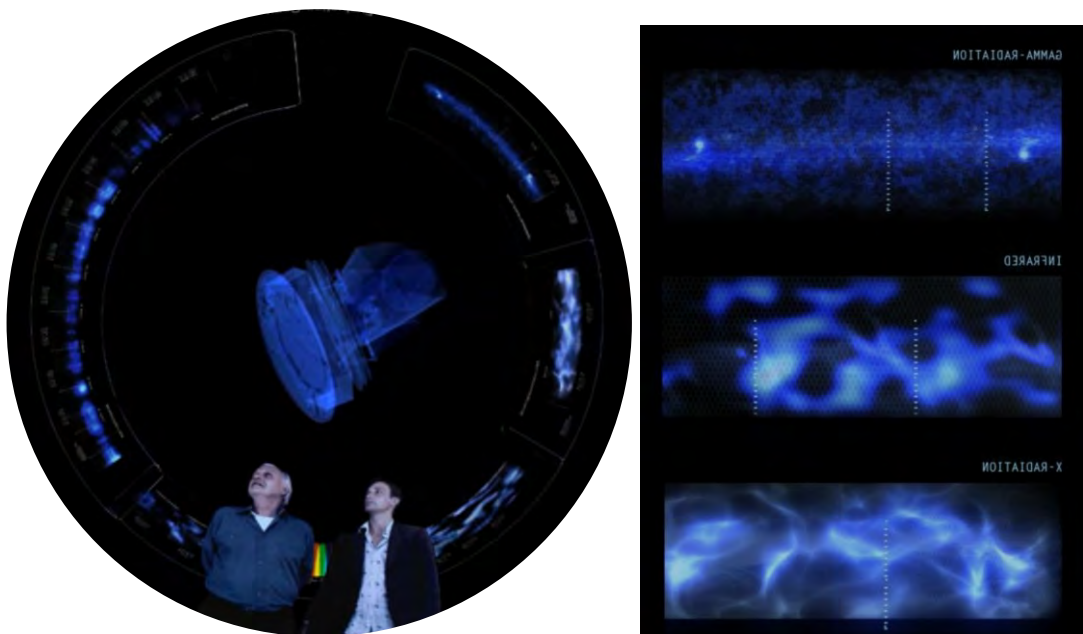
From the late Middle Ages until the present day, visuals have not been seen as possessing epistemic value amongst the natural sciences and engineering. Rather, they are merely understood as attachments or accompanying media, illustrating central logical and rational arguments (Mersch, 2006). Their inherent epistemic status and encoded visual knowledge is thus neglected—even though practically no scientific field manages to constitute itself without recourse to the visual. This can be proven, not only amongst visual-based disciplines such as geology, astronomy, or medical diagnosis, but also amongst the theoretical sciences, such as quantum mechanics, biochemistry, and genetics (Mersch, 2006). For example, in the context of new developments regarding chaos theory, mathematics provides evidence that the visualisation process is essential to the meaning of cognition: some substantial insights, such as fractal amounts or pattern recognition, can only be deducted from the realm of the visual (Heßler, 2006). This dissertation attempts to widen the capability of the visual, firstly through concepts such as diagrammatic thinking and the art of understanding, and later through dynamic models, digital space, and the passage concept.

Practical Work and Case Studies

In this section I am addressing important projects and productions that I have created, and which will be cited throughout this dissertation to illustrate my argument.⁵ At the beginning of my research, my continuous search for epistemological patterns or structures in visuals was most crucial. As Dieter

⁵ For more information, see the filmography in the Appendix of this dissertation. The projects can be viewed on the flash drive.

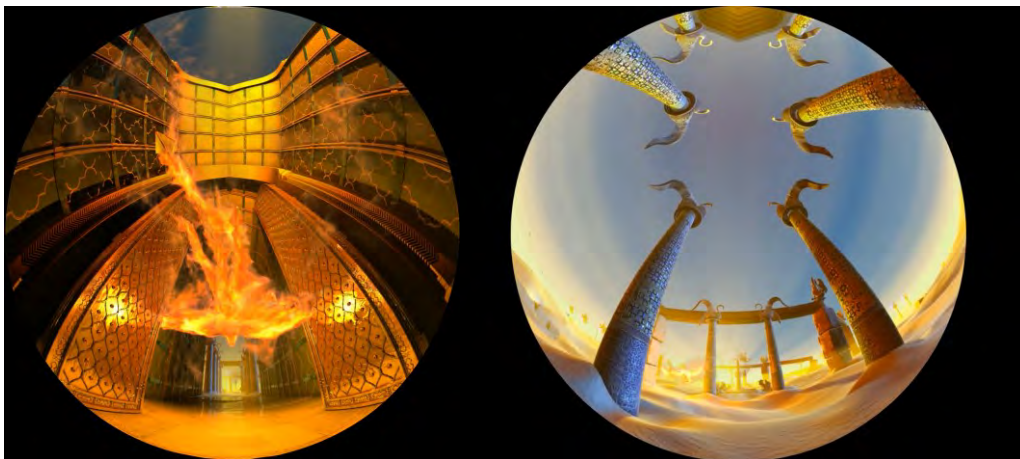
Mersch (2006) suggests, scientific visualisation through computer simulation tends to be based on two forms of invisibility. The first form of invisibility is the content of a given scientific research itself, which is in most cases invisible, whilst the second is that the conditions of its generation, such as algorithms or the specific function of a computer program, are equally invisible (Mersch, 2006). Therefore, Mersch (2006) states that the epistemic is fragile, since we can never fully know what we see exactly, as we never see through what we see. During my research into the epistemic visual and its fragile status already during my RDC2,⁶ I found an important connection to one of the scenes I produced for the fulldome production “Touching the Edge of the Universe” (Buczek, 2009).



⁶ A Research Development Confirmation (RDC) document involves three stages during the process of a PhD. The results of the research conducted in the course of this dissertation, especially regarding the epistemological function of the visual, can be found in the RDC2, accompanying the Appendix of this dissertation.

Figure 0.2. Electromagnetic spectrum. "Touching the Edge of the Universe," Isabella Buczek. 2009.⁷

In the scene illustrated in Figure 2, I tried to visualise and point towards that which cannot normally be observed—in other words, towards the invisibility in visuals. Here, I reveal the process of how astronomical images come into being, using the various wavelengths of the electromagnetic spectrum. Each image of a specific light spectrum was meant to reveal itself by showing its specific trace, or the structure of the wavelength from which it is formed. Normally images can only be perceived at their surface, or in other words, at "face value"—in their aesthetic sense, without revealing the technical and mathematical structures of their generation (Buczek, 2013; Mersch, 2006).⁸ I use further scenes from this fulldome production as a case study in order to illustrate the fisheye camera work, as well as the work done with actors in a 360° display in Chapter 5.



⁷ All figures including pictures or other visual material from my own projects and productions included in this dissertation are the property of the author.

⁸ Throughout my dissertation, I may refer to myself either using my maiden name of Buczek, or my married name of Beyer. This is done for clarity with regard to publications written before my name change.

Figure 0.3. Heavens of Copernicus. "Dream to Fly," 2013. Isabella Buczek and others. Collaborative project.

Another practical work is the fulldome show on which I worked (with, amongst others, production manager Maciej Ligowski and art director Paulina Majda) from 2010 to 2013, entitled "Dream to Fly" (2013; illustrated in Figure 2). The final scenes of this production are used as a case study in Chapter 5 in order to illustrate various different approaches, such as the spiral movement of the camera realised through the 360° visual.

The prototype piece "Unfolding" (Beyer & Weber, 2014) is intended to showcase the possibilities of the 360° space, both in spatial construction and in activation of the creation process. The prototype is intended to be complemented by an interactive eye-trigger component: the environment unfolds and manifests itself in a specific image segment in which the viewer, via the act of looking, both steers the camera and the creation process, as illustrated in Figure 3.

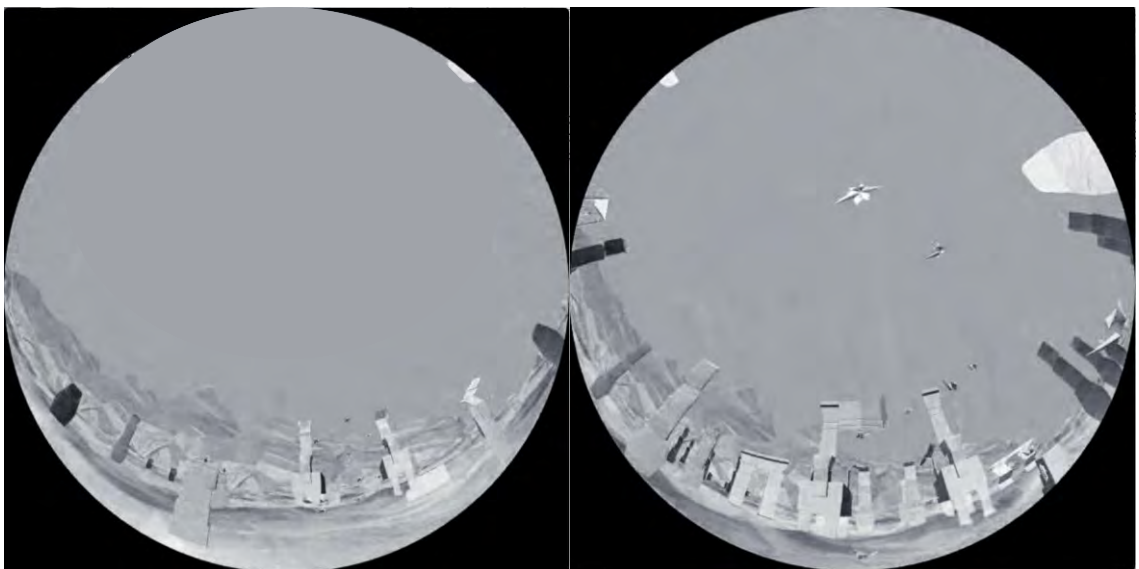


Figure 0.4. A slowly unfolding paper landscape on camera movement. "Unfolding," Isabella Beyer and Bob Weber, 2009.

The aim here is to empower the viewer. Not only is the viewer forming the narrative in an existing world; he or she also creates that world through setting his or her individual focus points in space. This provides the viewer maximum agency in the process. Further scenarios—for example, how a group experience would be possible by moving the camera collectively—would provide further promising avenues of investigation.

Another fulldome production that is used as a case study throughout this dissertation is “VIP” (Buczek & Weber, 2004); a project with specific tunnel sequences that function as passages between the scenes (see Figure 5

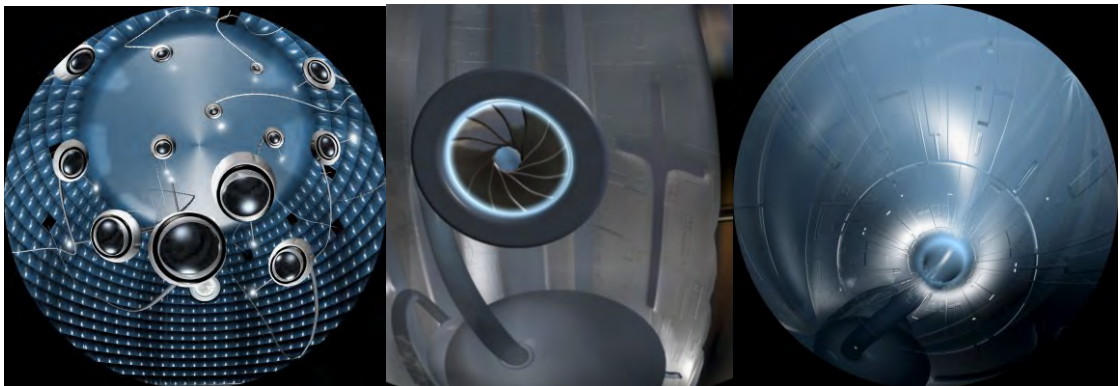


Figure 0.5. Camera memory room and 360° tunnel passages through the VIP urn. “VIP”, Isabella Buczek and Bob Weber, 2004.

In Chapter 5, “Himmelsscheibe von Nebra” [“Skydisc of Nebra”] (Buczek, 2007) is used to illustrate the “inside-out” potential of the IDE medium—the sense of being simultaneously within and without (see Figure 5). It also provides a metaphor for the creation process of spherical environments—from a limited projection space to the freedom of an infinite space for creation through the fulldome projection technology.



Figure 0.6. The skydisc emergence and the limited spherical world view of the Bronze Age. "Skydisc of Nebra," Isabella Buczek, 2007.

"Tauchgang: Die Expedition in die Tiefsee" ["Dive: The Expedition into the Deep"] (Buczek, 2007) is used to illustrate yet another approach to a passage sequence—this time as a continuous sinking experience (see Figure 6).

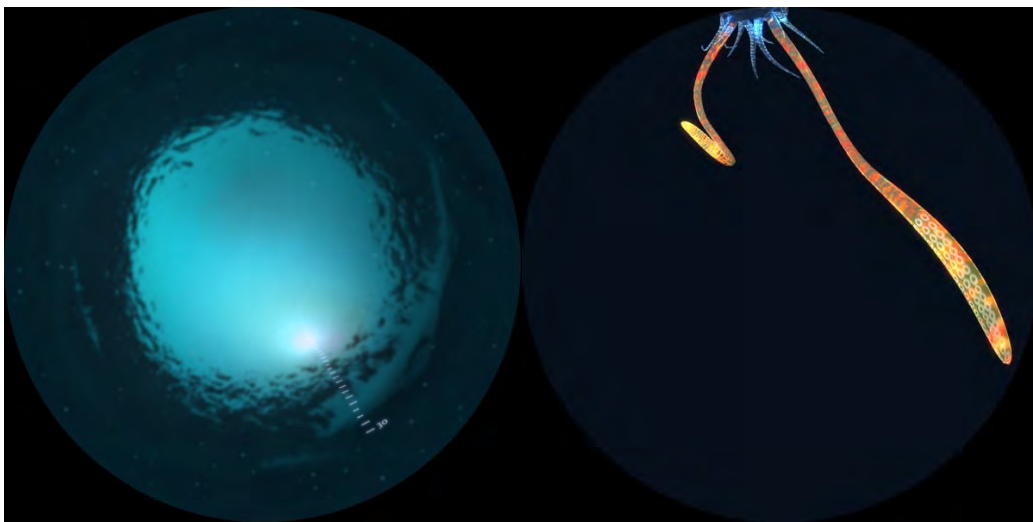


Figure 0.7. Sinking passage until the encounter with a squid. Dive: The Expedition into the Deep," Isabella Buczek, 2007.

In Figure 8, the artwork "Urban Vision" (Buczek, 2007) thematises the war between the material visual and the immaterial visual via a passage. Here, the passage is similar to a roller coaster ride.

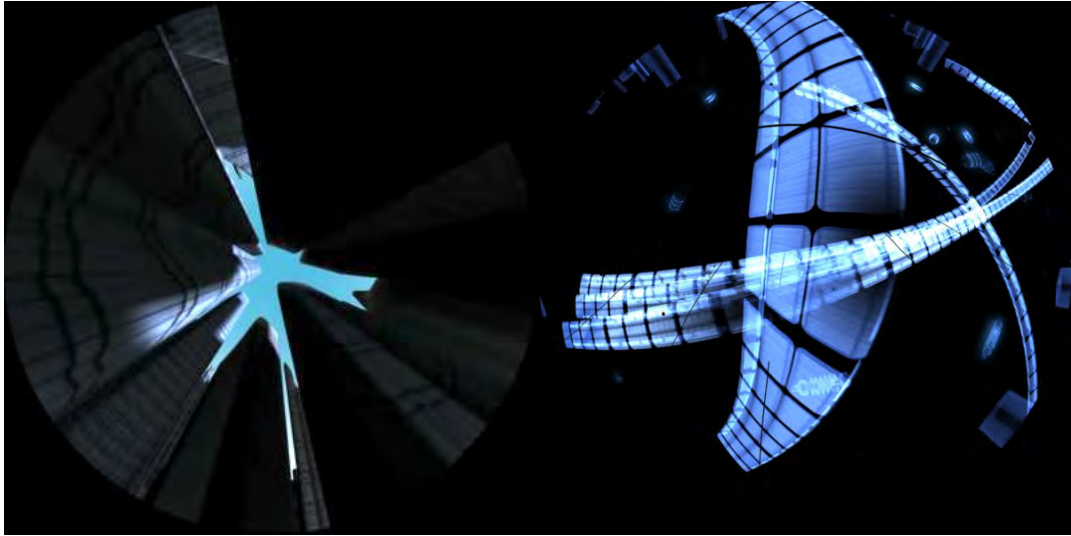


Figure 0.8. From materialization to digital dematerialization. “Urban Vision”, Isabella Buczek, 2007.

“Cuve Waters” (Beyer, 2013) is another work I created for the German Federal Ministry of Research and Education, demonstrating how real data—such as the water supply systems in Namibia—can be integrated into a three-dimensional, spherical narrative inside the IDE (see Figure 9).⁹

The work “Der dreiäugige Totenkopf” [“The Three-Eyed Death’s Head”] (visuals by Beyer, Oliwiak and Northdocks GmbH, 2018)—as part of the series “Die Drei ???” [“The Three Question Marks”]¹⁰—is used to describe a two-dimensional spherical production process and illustrates a poetic, visual approach to the mysterious unknown in spherical space (Figure 10), as explored in Chapter 5.

⁹ More information can be found at www.cuvewaters.net.

¹⁰ Die Drei ??? is a quite famous German audio drama series, which originates from the American detective book series the Three Investigators by Robert Arthur, Jr. 1964–1987. It is the first audio drama which made it to the fulldome medium thanks to Markus Schäfer.

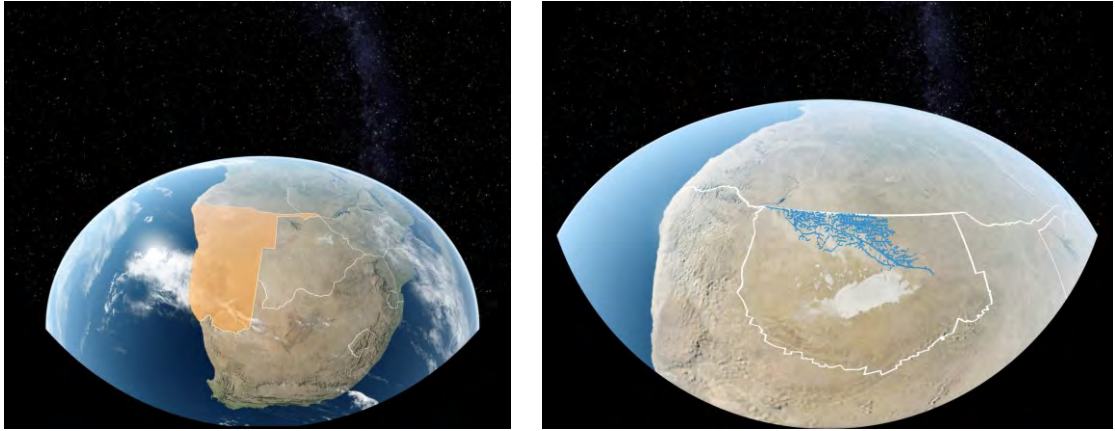


Figure 0.9. Scientific visualization of Namibia and its water supply system. "Cuve Waters", Isabella Beyer, 2013.

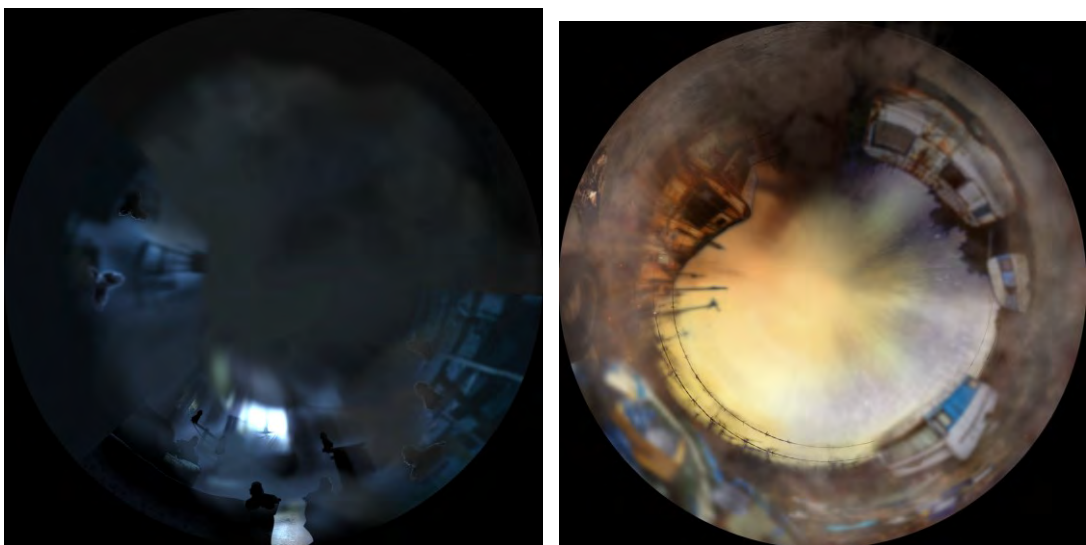


Figure 0.10. Mystery in the cellar with poodle puppets and at the motor camp. "The Three-Eyed Death's Head," Isabella Beyer and Natalia Oliwiak, 2018. X

The 360° wind turbine drone production (Beyer, 2017) was made to show a new VR interpretation of the lift-off effect shown at the World Fair during the 19th century. This production also uses the "inside-out" approach, the inside being a passage inside the wind turbine—from ground level to the machine room—achieved by placing the camera on an elevator. The outside (lift-off) passage was filmed via a drone from the outside, traversing the wind turbine. Comparing these two passages, the inside passage prepares the senses for a more

intensive experience when emerging into the outside, including a full panoramic view above the clouds. The history of the 360° IDE is described in Chapter 1, whilst new spatial interpretations of this original concept through VR are analysed in Chapter 5, demonstrating through this case study how the experience has changed throughout history, as illustrated in Figure 10.



Figure 0.11. Balloon ascent via the Cinéorama, Raoul Grimoin-Sanson, 1900. Drawing.¹¹

Figure 0.12. Drone ascent at a wind turbine watched on the oculus rift. Photograph, Isabella Beyer, 2017. (right)

The final case study, “Superhelden der Ozeane” [“Superheroes of the Deep Sea”] (Beyer & Magens, 2017), is used in Chapter 6, demonstrating how transmedia storytelling can be used, deploying VR and AR media formats alongside the fulldome medium of the IDE (see Figure 13).

¹¹ Retrieved May 13, 2016, from <https://mediartinnovation.com/2014/06/23/raoul-grmoin-sanson-cineorama-1900/>.

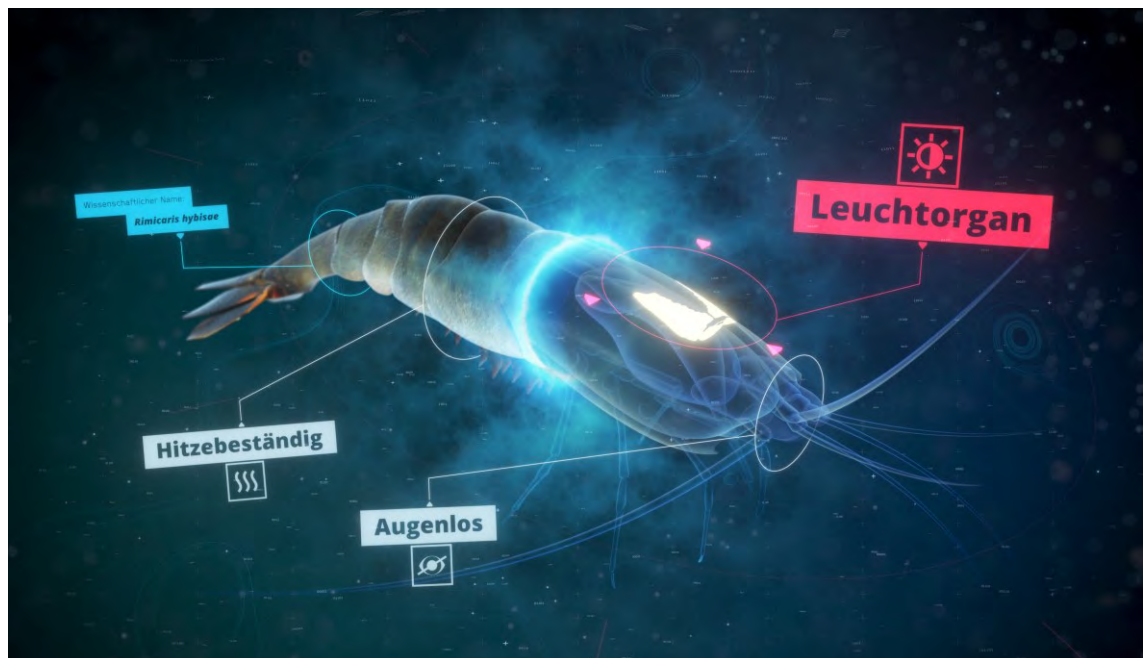


Figure 0.13. The eye-less shrimp inside the scan process. "Superheroes of the Deep Sea," Isabella Beyer and Michel Magens, 2017.

During recent years, the medium of the IDE has changed and developed—a development I described in my German publication "360°-Darstellungskonzepte im Wandel der Zeit" ["360° Performance Concepts Throughout the Centuries"], illustrating its transitional state as well as new 360° concepts (Beyer, 2015). A summary of this earlier work can be found in the conclusion of this dissertation, and this work is frequently cited throughout. I found spatial relations and scale comparison valuable in the context of epistemological concepts through my own work on "Superheroes of the Deep Sea," to which I refer in Chapter 5.

All of my fulldome projects have demonstrated that visual and spatial representation can be a key instrument for analysis in the process of gaining knowledge (see also Heßler & Mersch, 2009). Yet, how much can this cognition process be used to enrich the experience inside the space of the IDE? This question becomes even more relevant today. As Ryan Wyatt (2007), Director of the

Morrison Planetarium, states: “Planetarium audiences (and others) have an opportunity to experience storytelling rooted in the same data that researchers use to understand the complexities of the Universe” (p. 101). The main aim of contemporary science communication should thus be to transform the audience or general public into active participants in knowledge production, possibly through immersive experiences. How best to design such experiences is a primary concern of the research questions guiding this dissertation.

The Structure of This Dissertation

Chapter 1: Historical 360° Concepts and the 360° Creation Process Throughout the Centuries.

In order to answer the main research question — What is the epistemological function of immersive space as a knowledge instrument? — one has to elaborate its historical roots and see if there are historical precedents, models, and approaches that can frame the 360° visual space as a knowledge instrument. In order to answer this first research question accurately, three approaches were undertaken, addressed in three respective historical subchapters: “The Genesis of 360° Concepts”; “Seeing All with the Panorama”; and “The 360° (World) Creation Process Throughout the Centuries,” which form the first chapter of this dissertation. On the one hand, it could be argued that the genesis and usage of the 360° view itself play the main role in 360° artworks, empowering and intensifying the visual effects of travel experiences, lift-offs, or offering further perspectives and insights into natural phenomena. On the other hand, an investigation of historical concepts such as the Ovoid Theatre or the Cinéorama

in the 19th century (or later, the planetarium) could suggest that of greatest significance to these concepts is the transitional state, which merges scientific approaches with artistic presentations in various ways. The investigation of the creation process for spherical, immersive environments through history has revealed not only a technological change, but also presents more specifically how our thinking and understanding of—and acting within—spatial knowledge has shifted. The most significant achievement is the use of 360° visual space as a tool for knowledge production.

Chapter 2: Le Passage: The Concept and Model

Having elaborated the transitional function as the main quality of spherical concepts in Chapter 1, the second chapter thus focusses fully on passages and their transitional mechanism through diverse, yet cognate disciplines and fields of study, such as literature, architecture, cinema, performative cartography, and geographical visualisation, using scale and zoom, as well as other passage techniques. My aim here is to collate the different aspects of these passage concepts in order to build a taxonomy and thus enrich the passage concept itself, albeit with the requirement that it should be enacted or realised through media—ideally inside the 360° medium of the IDE.

Chapter 3: The Paradoxical State of Visual Models

Whilst comparing the Google Earth model with the DUA model, it became clear that passages between spatial data are possible in the first instance because a

model world has been built.¹² Once this was established, important research was undertaken on the topic of visual models—especially their capability to generate new knowledge. This avenue of research also led me to other models that are being created in both scientific practice and in visualisation laboratories, which I compared with the DUA. It struck me how important models are, and how strong and culturally dominant they can become. I pursued further model examples, ranging from active to more dynamic models and their simulation capabilities, portraying models as active knowledge instruments. Finally, questions such as how the quality of the passage design within such a model can be enriched through, for example, real-time simulation, are addressed.

Chapter 4: Tools of Thought: Artistic and Scientific Visualisations

Most important in my quest to answer my third research question—What design mechanisms, methods, and qualities can successfully merge the scientific approach with artistic visualisation?—was my search for epistemological patterns or structures in visuals. My aim was to find these in the technological laboratories of today, not least as both the sciences and the arts are capable of generating new knowledge, especially when they merge and collaborate. In my examinations of meaningful visuals that can act as knowledge tools, I revealed interesting mechanisms and techniques—for example, in the diagrammatic

¹² The DUA model has been developed and specifically adapted to a fulldome planetarium; an immersive dome environment developed by the American Museum of Natural History's Hayden Planetarium (see <https://www.amnh.org/our-research/hayden-planetarium/digital-universe/>).

approach and in the art of understanding. Both of these creation methods are described and analysed via examples of important artists and scientists in this chapter. The diverse confluences of these approaches also serve as important meeting points at which science and art can collaborate. Art can contribute significantly to scientific research, providing new methods and technological developments—most importantly, contributing to transdisciplinarity and knowledge generation.

Chapter 5: The IDE: The Taxonomy of a Passage Instrument

Finally, the IDE with its most recent fulldome and real-time capabilities will be presented as a possible passage instrument and will be deconstructed and analysed in terms of its different functions, parameters, and taxonomies in order to explore its function as a visualisation instrument and evaluate its potential to further processes of imagining and understanding. The passage itself is taken further to scale passages and chain comparisons from the micro to the macro, and to design techniques such as the spiral movement or kaleidoscopic arrangements. All of these techniques qualify the IDE—if used correctly as a passage instrument—as a cognitive tool that can aid the mind to travel beyond its existing knowledge horizon. The IDE thus becomes the tool par excellence for mind travel mediated by technology.

Chapter 6: Future 360° Concepts in IDE, VR, AR, and MR

In this chapter, the taxonomy established in the preceding chapter and the epistemological function of immersive, spherical spaces are expanded to encompass other media formats with the aim to enable a perspective shift from a sense of place towards a sense of planet. By means of a fourth and final research question, I will ask how much the contemporary media landscape influences the IDE medium. Additionally, the question of whether the IDE should adapt to new interactive applications, such as VR, or if VR should learn instead from the IDE, will be explored. The IDE's spherical passage concept will be compared and expanded to other 360° media formats such as VR, AR, or MR. A transmedia approach will be presented via the case study "Superheroes of the

Deep Sea” in order to reveal its potential for storytelling and precisely its epistemic function in scale comparisons through media blending with the aim to create a more lasting experience.

Conclusion: Future 360° Passage Concepts and Their Role as New Knowledge Instruments

The conclusion draws finally the research questions and answers together, providing a glimpse into the 360° future, presenting the passage concept in immersive spaces as a knowledge instrument and also as a valid future concept in its own right. Most significantly, and as stated in the abstract of this dissertation, I will argue that the IDE is not disconnected from its wider contextual media landscape, instead being plugged into the rapid development of new technologies, such as VR, AR, and MR. Therefore, the IDE medium offers a productive space in which all these media formats can meet, co-exist, cross, and blend together, as the work undertaken at the Satosphere (SAT) in Montreal, Canada, illustrates. This space of coexistence can offer passages between the virtual and the real, in-between the different media formats and inside the creation process of a new, dynamic world model. When used correctly inside the IDE, the passage concept can not only exist in its current form, but also develop further into a powerful epistemic instrument.

1. Historical 360° Concepts and Creation

As explained in the introduction to this dissertation, in order to answer the central research question of what the epistemological function of immersive space as a knowledge instrument is, it is first of all important to ask whether there are historical precedents, models, and concepts that can frame the 360° visual space as a knowledge instrument, and that can reach epistemological insights that other media formats are not capable of. In order to explore this question, three approaches were undertaken, resulting in three subchapters that together comprise the first chapter of this dissertation: “The Genesis of 360° Concepts”; “Seeing All with the Panorama”; and “The 360° (World) Creation Process Throughout the Centuries.”

This chapter discusses concepts for different 360° media, defined as falling under the categories of all-around view and passage, in a historical context. The genesis of the 360° moving image and the emergence of the medium of the planetarium will be outlined, illustrating their non-parallel development. A particular emphasis is placed on the epistemological function of the visual 360° space as a knowledge production tool that merges scientific approaches with artistic presentations in various ways. Whilst the first subchapter addresses the genesis of various historical 360° concepts, the second subchapter focusses on the panorama and its all-around view as a historical medium that has recently experienced a revival. In the final subsection, I will zoom in on the production

process of fulldome environments throughout the centuries, highlighting were we are today.

1.1. The Genesis of 360° Concepts

Implementations of elaborated visual 360° concepts are especially significant today, and there is much to learn from historical approaches. Many contemporary representational 360° concepts are not in reality particularly novel. Several have been used already in earlier times, such as the lift-off the earth's surface. There is an enormous amount of visual content being developed for the 360° medium today, yet its quality varies enormously. For example: in some planetarium programmes, the 360° medium is only realised as a curved cinema canvas, the content thus appearing as a stretched wallpaper, sometimes accidentally distorted through the dome's shape because of incorrect preparation of the visual material itself. This causes the medium itself to become corrupted or invalidated. However, in other programmes one can find traces of more elaborate visual realisations of the medium, which use the depth of the projected space to fully exploit its visual impact. Such implementations cause the projection space under the dome to become an epistemic instrument, either enabling a passage through time and space, or opening up new possibilities by means of the 360° perspective. These specific 360° representations closely follow, either consciously or unconsciously, their historical roots. The following subchapter will foreground some of these historical concepts, such as the Globe of Gottorf, the Georama, the Zeiss planetarium, panorama, the Cinéorama, the Swissorama, and the Ovoid Theatre, and their origins in order to understand

their initial purpose, the establishing concepts that underpin them, and their method of realisation.

1.1.1. The Globe of Gottorf

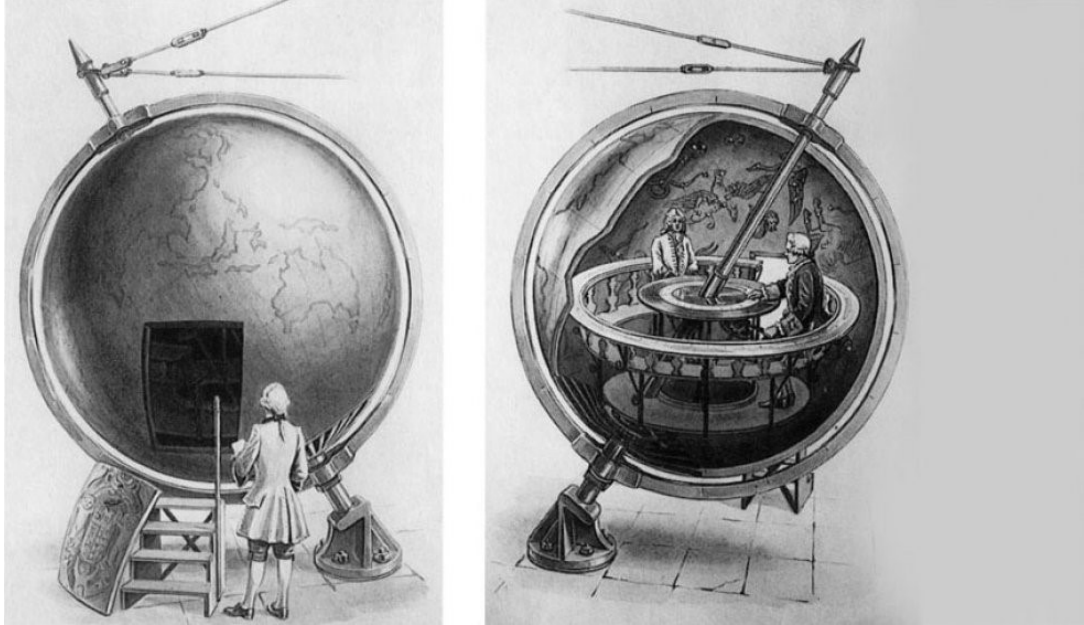


Figure 1.1. The Globe of Gottorf, 1650–1664. Drawing by W. J. Peredery, Lomonosov Museum, Saint Petersburg, Russia.¹

In the 17th century, the Gottorf marvel—the very first combined planetarium and globe—was built by Adam Olearius (born Ölschläger) for the German Duke Friedrich III, close to his palace, Gottorf, in Northern Germany near Schleswig (see Figure 1.1). It was the largest globe of its time, with a diameter of 3.11 m. Dr. Felix Lühning (1997), a historian and astronomer, suggests that Olearius was probably very well-educated, and therefore able to take inspiration from earlier globes. These possible sources of inspiration range from the Iranian King Shāpūr and his celestial globe—a spherical astrolabe (1144; Figure 1.2)—to the

¹ Retrieved May 4, 2015, from http://www.monumenteonline.de/08/05/sonderthema/10_Globen.php.

mathematician Archimedes of Syracuse (287–212 BC), with his first mechanical planetariums, known as armillary spheres (Lühning, 1997).



Figure 1.2. Possibly the astrolabe of the Iranian King Shāpūr, 1144, one of the three oldest world treasures. Globe Celeste, signed Yunus b. al-Husayn al-Asturlabi, Louvre, Paris. © Musée du Louvre.²

The representational concept of Globe of Gottorf was particularly significant because it combined the cartographies of the earth and sky in one model. The Duke and his librarian sought to combine the earth and the sky to create an exemplary, scale copy of both earth and cosmos (Lühning, 1997). This was unusual for that time, as globes were mostly representing the known earth's cartography, the armillary spheres representing the known celestial movement

² Retrieved May 6, 2015, from: http://cartelfr.louvre.fr/cartelfr/visite?srv=car_not_frame&idNotice=34181

of a partial solar system, limited to the earth, moon, sun, and the five planets known at that time in a geocentric representation.

Therefore, both the concept and execution of the Globe of Gottorf were extraordinary. The accumulation of knowledge through the collection of stuffed animals, exotic plants, and other objects, as well as the associated creation of the so-called "*Wunderkammern*" situated within private homes was commonplace among the rich, albeit with access restricted to the owner and invited guests. These rooms are regarded as the first forms of museums. However, collecting knowledge of the earth and sky, in addition to creating a new model as a container for that knowledge—with its specific functionality—was, and remains, very unusual for that time. (Lühning, 1997)

Even more so, if one takes into account the contextual setting of the overall concept. The Globe of Gottorf was, next to the Spheara Copernicana³, without doubt the second most elaborate model in the Duke's park, but it was only one part of a larger arrangement. The globe was embedded in a specific context, which included the garden and its two buildings: the globe house, including the Globe of Gottorf; and the Duke's castle, including the Spheara Copernicana. The overall concept was to illustrate the whole creation process, from the macro cosmos—the known universe at the time, as depicted by the Globe of Gottorf and the Spheara Copernicana—to the micro cosmos of the garden, including exotic

³ Spheara Copernicana is an armillary sphere, which demonstrates planetary motion and the heliocentric worldview of Copernicus. (Lühning, 1997)

plants and water lying between the two buildings as well as around them (Figure 1.3). The Duke's ultimate intention was to give the public open access to his property.



Figure 1.3. Overview of the dukes castle and the baroque garden. Drawing by Dr Felix Lühning, © Felix Lühning. personal communication, [October, 25, 2015]



Figure 1.4. Photograph of the property today. © Stiftung Schleswig-Holsteinische Landesmuseen Schloss Gottorf.⁴

⁴ Retrieved May 8, 2015, from: <http://www.museen-sh.de/museum/6890738>

Upon entering the globe hall, one passed the door, upon which the portraits of Nicolaus Copernicus and Tycho Brahe were placed—an acknowledgement of the eminent astronomical authorities of the time. The basal area of the globe hall took nearly the space of the whole ground floor. The hall had a stucco ceiling, was decorated in white, and possessed numerous windows so that the globe could appear in all its glory, dominating the space without any distractions. The hall needed to be traversed in order to reach the globe. Once approached, one could admire it from the ground by looking up and walking around it (Lühning, 1997).

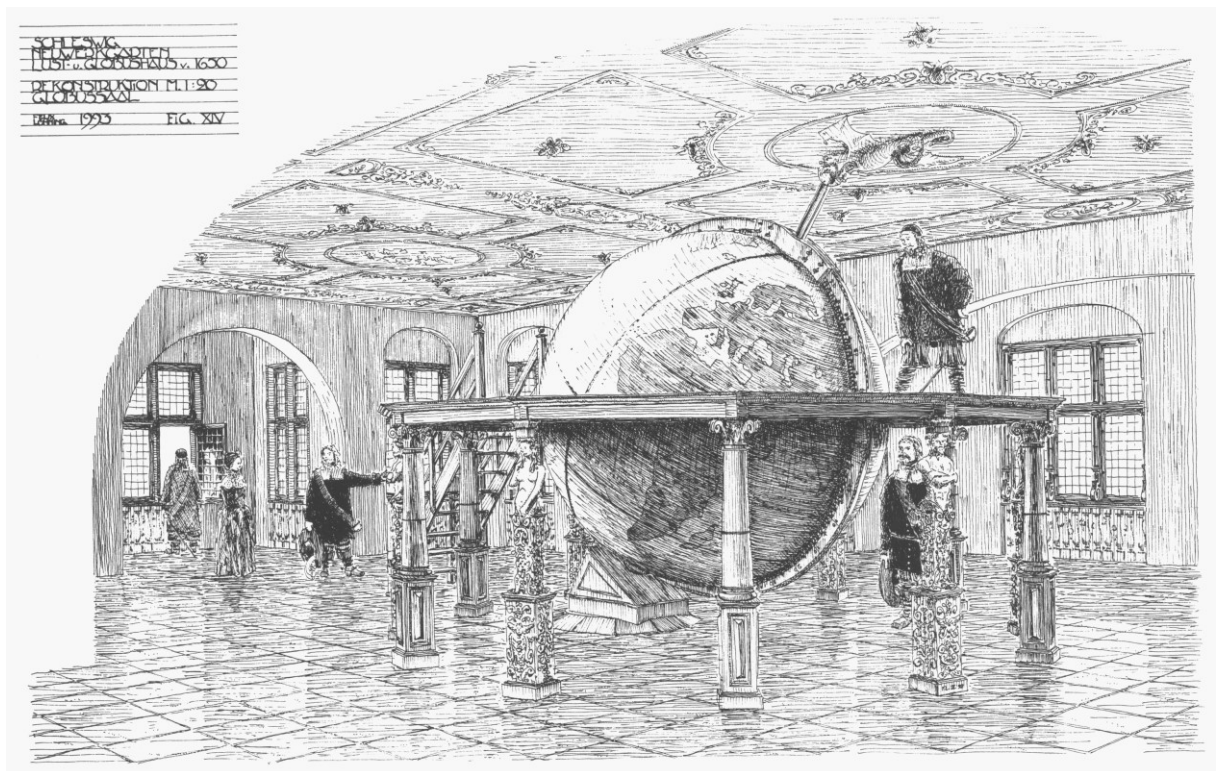


Figure 1.5. The Globe of Gottorf in the globus hall. Source: Dr. Felix Lühning. personal communication, [October, 25, 2015]

The globe itself stood in a twelve-sided horizontal ring with Corinthian columns and herm pillars (see Figure 1.5). On its outer surface, the world as known at that time—Europe, Africa, and Asia—was carefully drawn with coloured country

boundaries, all kinds of animals according to country, fleets of vessels, sea wonders, and fish. The cartography of its surface was based upon the work of the Amsterdam map-publishing company Willem Janszoon Blaeu and Joan Blaeu, and their commercial globes (Lühning, 1997; see Figure 1.6).



Figure 1.6. Cartographic surface of the Globe of Gottorf, photography in Lübeck 1945 . Source: Dr Felix Lühning. personal communication, [October, 25, 2015]

One could also climb some stairs onto the raised twelve-sided horizontal ring and walk around the globe, looking down upon its cartography (Figure 1.5). Once the globe's outer surface had been fully contemplated, one could decide to pass through a hatch (visible in Figure 1.5) to experience the inside of the globe.



Figure 1.7. The night sky inside the Globe of Gottorf. Source: Dr. Felix Lühning. personal communication, [October, 25, 2015]

On the inner curved surface, one could see the starry sky with a thousand stars shown in six different sizes in order to indicate their actual brightness ratio. The stars consisted of nail heads formed from gilt brass to eight-ray stars. The background was painted blue with the typical figurative depiction of constellations of that time, resuming in a 360° painting (Figure 1.7) enclosed inside the Globe of Gottorf (Lühning, 1997). At the time it must have been an impressive experience—its spherical pictorial arrangement strongly reminiscent of contemporary planetariums.

The unique mechanism of the Globe of Gottorf allowed the stars to move interactively. This movement was made possible by the fact that the globe was supported on a wrought-iron axis fixed in the basement inside a mill-stone and attached to a beam of the third floor globe hall ceiling (see Figure 1.7).

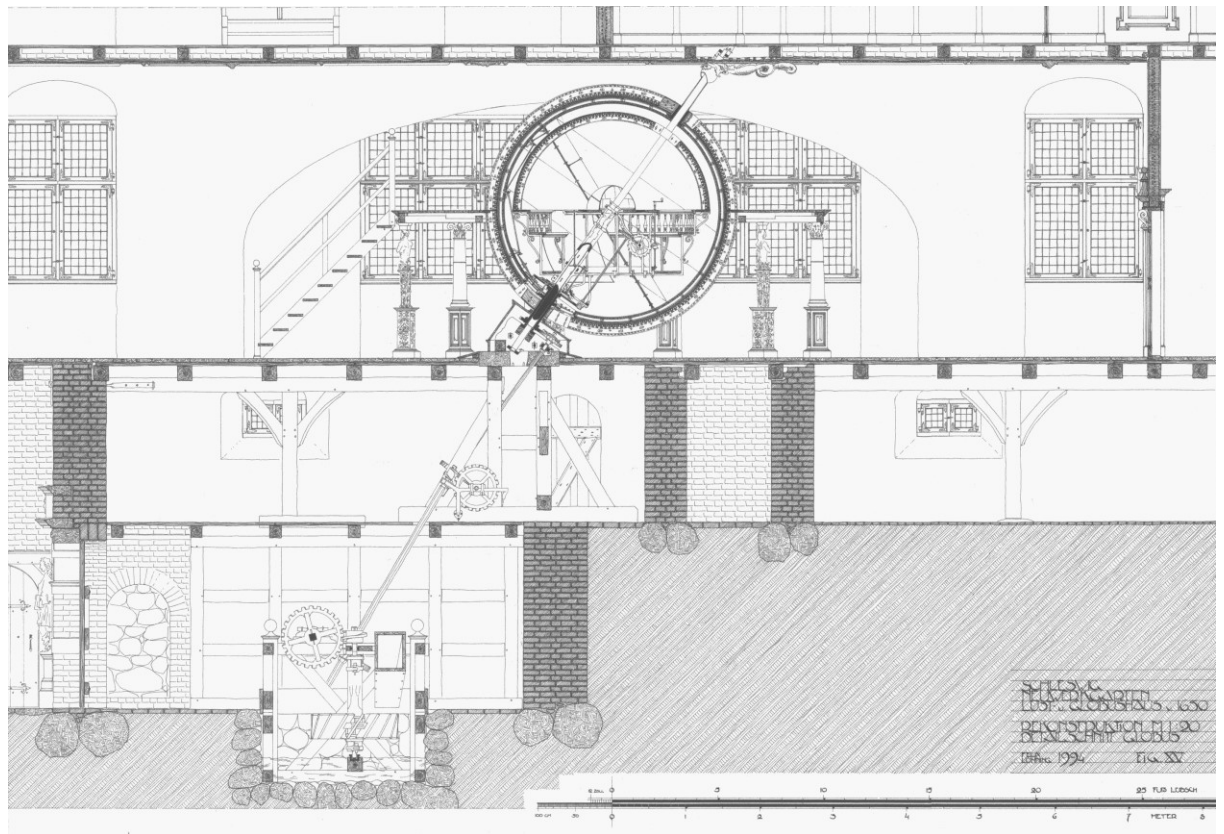


Figure 1.8. The hidden functionality of the Globe of Gottorf. Drawing by Dr Felix Lühning. personal communication, [October, 25, 2015]

A ring-shaped bench was attached to the axis. The sphere could be rotated around the axis by means of water power. The sphere could accommodate up to 12 persons to observe the movement of the starry sky. The declination of the axis, at $54^{\circ} 30'$ was in accordance with the latitude of Schleswig. The purpose of this arrangement was that, once inside, one would see the local sky above Schleswig (Lühning, 1997). This function is still duplicated in various planetariums across the world in order to locate the audiences inside their known environment before, inside, or after the programme. This satisfies the need for spatial identification, orientation, and attachment before taking the audience from the ground, out into the universe (see Chapter 6 for an exploration of narrative journeys inside contemporary planetariums).

In the middle of the sphere, a copper half-globe was placed on the table's top surface, symbolising the earth as the centre of the firmament. Around the table-globe lay a horizontal ring with geographical longitudes of various geographical locations (see Figure 1.9). Once the large globe was put into motion, two pointers skimmed along the ring, indicating at which location on earth it was midday or midnight. Along the ecliptic a sprocket was moved, on which a crystal model of the sun was mounted. The sun thus performed its daily (sunrise and sunset) and annual (changing solar altitude) cycles. Lunar and planetary motions could not be incorporated into the mechanical concept due to their complicated orbital motions. Therefore, the Spheara Copernicana includes a miniature model of the Globe of Gottorf, which is equipped with planetary motion and the then “new” heliocentric worldview based on the work of Copernicus (Lühning, 1997).

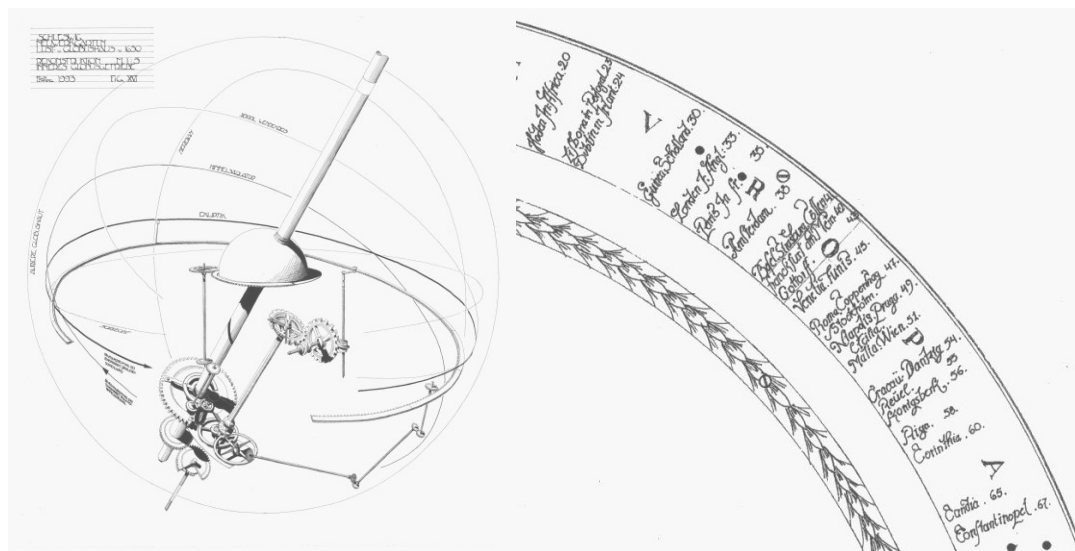


Figure 1.9. The inside functionality of the Globe of Gottorf. Source: Dr. Felix Lühning, personal communication, [October, 25, 2015]

The whole globe could be moved manually through the use of a hand crank on the inside. A whole rotation could be sped up to 15 minutes, which was sufficient

to present the visitor with a whole day's sky motion. In this respect, the Globe of Gottorf can be recognised as the first planetarium in history that was capable of demonstrating sky phenomena "live." The ability of the globe to perform a 24-hour rotation in "real-time" was a novel innovation, realised through the use of water power. To this end, in the basement, a wooden water wheel was placed, which transferred its motion through a four-step worm gear to the main globe. The water was lead through tubes to the water wheel and afterwards flowed out into the "Herkulesteich" pond (Lühning, 1997).

Contrary to Dr Felix Lühning (1997), who understands the "real-time" mechanism as simply another technical refinement, I suggest that the concept was an early manifestation of the desire to demonstrate dynamic and actual life cycles with regard to celestial motion. This desire has continued throughout history right up to the present day, and has been partially accomplished—at least as far as current technology will allow it (see Chapter 6).

1.1.2. The Georama and the Concept of the All-Around View



Figure 1.10. The Interior of the Georama. Georama at Champs-Elysees, Paris, France, illustration from *L'illustration, Journal Universel*, No 166, Volume VII, May 2, 1846. © Österreichische Nationalbibliothek.⁵

One of the first realised concepts of a geographical all-around view inside a sphere is embodied in the Georama, a giant globe in Paris (Figure 1.10). The globe was designed by the Frenchman Charles-Antoine Delanglard in 1822. The impetus that led to the construction of the Georama was to communicate the geographical knowledge of the time in a new way, presenting it in layman's terms and thus making it accessible to the general public. One of the important characteristics of the Georama that qualifies an immersive space is its ability to draw “immense crowds into closed environments, with the world laid out in spectacle,” enabling one to “project oneself imaginatively” (Grau, 2003, p.8).

⁵ Retrieved May 4, 2015, from http://www.onb.ac.at/images/SIAWD/georama_zoom.jpg.

At the time, the depiction of the earth's surface in all its detail and scale presented a significant technical challenge. Commercially available globes could only depict partial views. For the Georama, an innovative technique was employed. The earth's surface was reversed and displayed on the inside of the globe, covering its whole inner surface. In this way, a holistic all-around view encompassing most detail was facilitated. Murray described "The value of the Georama was so highly appreciated by the Geographical Society of Paris, that the French Government granted to M. Guérin a piece of ground in the Champs Elysees ..., where it is now open to the public" (Murray, 1846, p. xxxiv) The viewer was guided to the observation deck via a spiral staircase that rose from the floor. An observation deck was built in the centre of the sphere, enabling visitors to gain a 360° all-round view of the whole surface of the earth. The achievement of this all-around view required the Parisian globe to have a 30 feet in diameter (Murray, 1846, p. xxxiv) —the size necessary in order to have enough space on the inside sphere to accommodate the earth's geography.

Initially, the Georama enjoyed great success, but despite the support of well-known scientists such as Alexander von Humboldt, after a number of years audiences dwindled and eventually the Georama was dismantled—only to be rebuilt eight years later in 1830, again in France, by Charles Auguste Guérin (Beyer, 2015). The concept of the internal globe was approved by the Academy of Sciences around the same time and recommended for the education of geography. In an article published in the French periodical *L'illustration: Journal Universel*, the author advises to locate georamas in every larger city (Murray, 1846).

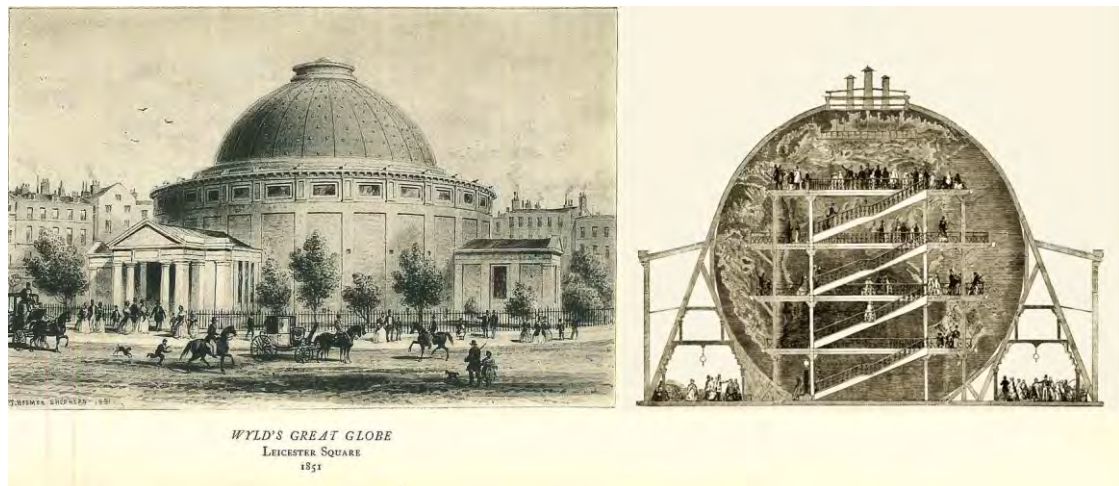


Figure 1.11. Exterior View of Wyld's Great Globe, Leicester Square, 1851 in Sheppard FHW (ed). Survey of London, The Parish of St. Anne Soho, Vol. 34, 1966. Interior View. Wyld's Great Globe. 1851 (n.n.) .⁶

The concept of the all-around view was again employed, this time for the Great Exhibition, under the name of the Great Globe, built by James Wyld in London, 1851 (Figure 1.11). The maps on the Great Globe were based on knowledge gained during the great expeditions, which were accomplished in the first half of the 19th century in Africa and North America.

Despite advances in both knowledge and realisation, this attraction also faced competition, especially in a town like London, arising from cycloramas, panoramas such as "Panorama of the Crystal Palace" (nn, 1851)".⁷ The panorama, however, was nothing new at that time: one of the first ones was accomplished already in 1793, a view of London from the Albion Mills by Robert Barker and his son Aston Barker being on display in the new rotunda in

⁶ Retrieved May 4, 2015, from http://en.wikipedia.org/wiki/Wyld%27s_Great_Globe.

⁷ Further attraction was for instance the Grand Panorama of the Great Exhibition of All Nations, 1851, which can be retrieved here: <https://www.pbagalleries.com/view-auctions/catalog/id/105/lot/29035/The-Illustrated-London-News-Grand-Panorama-of-the-Great-Exhibition-of-All-Nations-1851>

Leicester Square. After the death of Robert Burford in 1861, no new panoramas were built in London. (Comment, 1999, p. 27-28) The static all-around view from the Great Globe undoubtedly had most impact on first time visitors, but after a while the effect of this stimulus waned and as a result the Great Globe fell prey to the same fate as its predecessors.

Certain parallels with contemporary fulldome projections, which share the same features of all-around view experiences, are apparent. Thus, here the questions arise: Could the contemporary fulldome planetarium possibly succumb to the same fate as the historical concepts outlined above? Alternatively, is the digital transformation—also arriving in the fulldome world, enabling new forms of utilisation—enough to prevent the medium succumbing to the same fate, perhaps even fuelling an enormous growth in the number of fulldome planetariums all over the world? What benefits or additional value develop in the medium when it is combined with interactive elements?

1.1.3. The Zeiss Planetarium



Figure 1.12. The Birth of the First Zeiss Planetarium, Jena, Germany. © Zeiss-Planetarium Jena

The concept of the all-around view gained more and more popularity amongst amateur astronomers in Jena and Munich during the 19th century. In 1913, Oskar von Miller commissioned Carl Zeiss Jena to create a planetarium for the Deutsches Museum in Munich (see Figure 1.12). During the realisation of the project, the previous flat ceiling planetarium in Munich evolved into a dome-planetarium at Jena (see Figure 3.4 The Zeiss Copernican Planetarium [Deutsches Museum, 1924] for the flat version). In August 1923, on the roof of the Zeiss factory in Jena, for the first time visitors witnessed an artificially projected starry sky—an optical simulation space inside a spherical building [Beyer, 2015].

The mechanical engineer Walther Bauersfeld succeeded in building the projection planetarium, consisting of a 16 m cupola, a geodesic construction combined with a new shotcrete technique by the company Dyckerhoff & Widmann (Hellmuth, 2000). In the centre of the cupola, the very first star projector, the Zeiss Model I, was placed, projecting 4500 stars on the firmament—a star density that is already on the limits of the observable in the real sky due to light pollution and weather conditions. As a result of this, the first Zeiss planetarium has been widely described as the “Wonder of Jena” in the history of the planetarium (Krausse, 2006). Bauersfeld’s planetarium decisively shaped, through a worldwide distribution, the prevailing mental picture and understanding of the cosmos in the 1920s.

As a result of the above, it becomes even more important to understand the genesis, evolution, and concept behind the first projection planetarium.

Bauersfeld’s aim was not only to create an all-around view of the starry sky—for example, in the same static state as the Georama—but to open up the starry sky to experimentation, by being able to manipulate and gain insight into natural phenomena that otherwise cannot be observed in a human lifetime. His belief was that men should not have to wait for centuries in order to observe celestial motion, but be able to observe the natural spectacle in minutes on the planetarium cupola—as often as necessary—so that each time, with each repetition, a new insight might be discovered (Krausse, 2006).

In this sense, his intention was to create a learning environment in which natural phenomena can be made perceivable to the human sensorium (Hanisch & Bucher, 2006).

Even when an artificial simulation of the sky is repeatedly played over and over again, it remains only a replica or facsimile of the natural phenomenon—some of which can be seen with the naked eye. Thus, why can an artificial simulation of the sky be regarded as possessing epistemic value in the sense of enabling new insights? How significant a role does the 360° all-around view play? In order to answer these questions, one has to take a closer look at the mechanical capabilities of the planetarium projector, the Zeiss Model I (see Figure 1.13). Already by then, the projection included all stars visible from earth—around 4000 stars.



Figure 1.13. The Zeiss Model I, showing the first Zeiss planetarium in Germany in the Technik Museum Munich (1925). Photograph archived at the Carl Zeiss Archives.

The Zeiss planetarium also contained a complex mechanical model of the planetary orbits, which allowed one to influence the celestial bodies. Each planet

had its own lamp, but they were synchronised through a complicated mechanism; a gear. This mechanism allowed the sky to be simulated for the first time—the daily and annual movements for any given timeframe or geographical location on the northern hemisphere. Von Herrmann (2018) points out that the first planetarium incorporated already the whole history of knowledge of astrophotographic measurement of the starry sky, it grounds the complex starry sky, makes it tangible and even more importantly steerable. The *steerable* function and its importance will be further explained in proceeding chapters, as is the integration of contemporary technological advances in navigation.

The 360° all-around view was, and remains, essential to complete the illusion of being under the natural firmament and looking up into the stars. It immerses the audience into the night sky, surrounding them and situating them automatically inside the theme, such as observing the stars during the actual night at the actual location—a natural phenomenon can be observed during a timeframe of several hundred years. Experiencing the night sky was thus made accessible (Max Wolf cited in Krausse, 2006, p. 59). Besides the planetarium, the all-around view played an important role in other fields in the same way as the panorama became a mass medium before the advent of cinema (Oettermann, 1980, p. 31).

1.1.4. The Panorama Era

At the Exposition Universelle—a world's fair held in Paris in 1900—many panoramic paintings were presented. Therefore, it is often referred to as a

panoramic manifest—one of the last before the arrival of cinema (Comment, 1999). In this subsection, the specificity of the panorama will be examined through the example of a very special Polish panorama known as the Racławice Panorama, which was exhibited in Budapest (see Figure 1.14) and has, up to the present day, received millions of visitors, due not only to its intense all-around visual experience and its ongoing volatility over the last 123 years since its creation, but also because of its politically charged theme. It was originally built in Lwów, in modern-day Ukraine.⁸



Figure 1.14. Battle of Racławice. Panorama. Wojciech Kossak, 1982.⁹

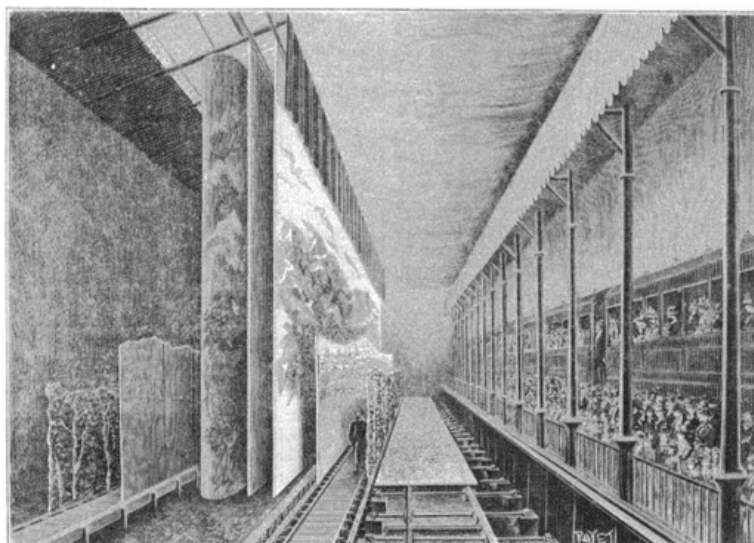
The Racławice Panorama is one of the very few preserved relics of the 19th-century panorama era, and can be found in Wrocław, Poland. The panorama is an important example of the 19th-century mass medium, and the oldest in Poland. The enormous cycloramic painting (15 × 114 m), depicting the Battle of Racławice, was completed in July 1893. Polish volunteers armed only with scythes fought under Tadeusz Kościuszko against the Russian army commanded by General Alexander Tormasov. I suggest the Polish victory in this battle was

⁸ Information retrieved from <https://visitwroclaw.eu/de/ort/panorama-von-raclawice-wroclaw>

⁹ Retrieved from: <https://www.polska.pl/arts/visual-arts/raclawice-panorama-wroclaw/>

very important for the nation, especially in subsequent years when it suffered both the loss of its independence and communist rule. For the all-around view, different scenes of the battle were depicted, each to be viewed from different angles. A particular perspective and distortion was used, as well as an artificial terrain to create a feeling of “being there,” inside the confrontation. Thanks to modern 360° video possibilities, the panorama can be viewed online in its entirety.¹⁰

The 1900 Paris Exposition Universelle is also famous for giving a stage to extended panorama techniques, such as the Cinéorama, Mareorama, and Le Transsibérien-Panorama Mouvant [The Trans-Siberian Railway Panorama], which were performed for huge audiences. It raised the medium of the panorama to new technological heights. For the Mareorama, a whole ship as well as a panorama canvas were moved by hydraulic power in order to create the illusion of being on a sailing trip (Skinner, 2014, p.81).



¹⁰ See <http://wroclaw360.pl/miejsce.php?q=220>.

Figure 1.15. The Trans-Siberian Railway Panorama, print, from *La Nature* (May 1900). Bibliotheque Nationale de France, Paris

For the Trans-Siberian Railway Panorama, four layered, enormously long panoramas to the left were moved beside real railway compartments (to be seen on the right side in Figure 1.15) at different velocities to induce a feeling of being on a train journey to Siberia, passing different cities and natural landscapes. (Ruoff, 2006)

1.1.5. The Lift-Off with the Cinéorama

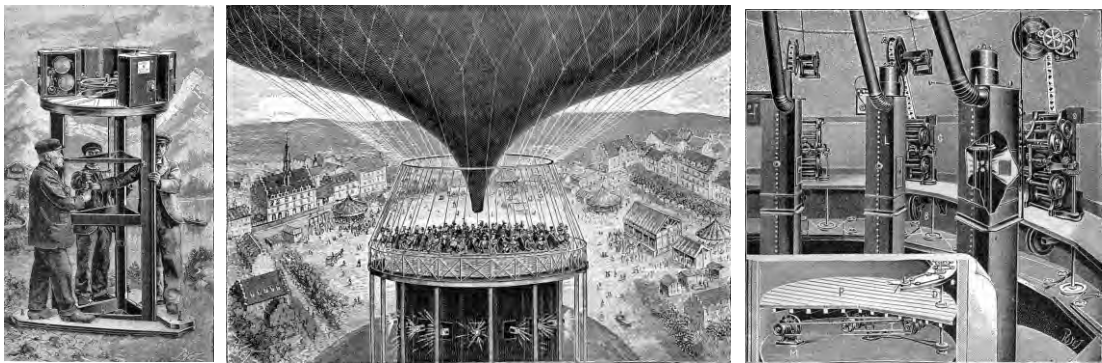


Figure 1.16. Balloon ascent via the Cinéorama. General View of the Interior, Raoul Grimoin-Sanson, 1900. Drawing in *Scientific American* le 1er septembre 1900.¹¹

Combining the technique of panorama painting and the recently invented technology of cinema in a single, unified performance, the Cinéorama was an early 360° film system used not only as an experiment, but also as an amusement ride at the Exposition Universelle in 1900. It was devised by Raoul Grimoin-Sanson, who tried to transfer the very popular panorama paintings into the new medium of the motion picture. At the fair, he tried to simulate a ride in a

¹¹ Retrieved May 13, 2016, from <https://mediartinnovation.com/2014/06/23/raoul-grimoin-sanson-cineorama-1900/>.

hot air balloon over Paris. Construction of the Cinéorama took place directly beneath the Eiffel tower. Inside a round building, 30 m in diameter, 10 projectors were built inside another concrete cylinder of 5 m in diameter. Above the projection cylinder a balloon gondola was placed, which was used as an audience platform accommodating up to 200 individuals. In order to complete the illusion of a hot air balloon ride, above the gondola a half balloon cover was suspended. Ten canvases measuring 9 x 9 m were placed on the rotunda walls. The measurements imply that Grimoin-Sanson originally intended to install his system in pre-existing panorama rotundas (Das Lexikon der Filmbegriffe, Wulf & Lenk, 2012).¹² In order to fill the canvases with seamless panoramic film, a camera system consisting of 10 individual cameras, arranged in a star shape (see Figure 1.16) on a circular wooden plate, had to be constructed. The cameras were placed on a rack above head height. Via a hand cranking system, the 70 mm film could be exposed synchronically in each camera via a very complicated, heavy and static recording method—the rack had to be placed inside an actual balloon. In this way, Tuileries Gardens was recorded from each of the 10 angles, whilst the balloon rose 400 m above. For the end of the film, the ascent was played backwards to simulate a descent. It is known that the recordings took place in Europe and North Africa. Some references also describe a much longer experience, involving a trip to England, Spain, and the Sahara. Some sources say it was only running for two days, because the projectors developed too much heat and the attraction had to be closed down for safety reasons.

¹² Retrieved from <http://filmlexikon.uni-kiel.de/index.php?action=lexikon&tag=det&id=6886>

The lift-off experience could be simulated through this enormous effort of building the balloon gondola arrangement inside a rotunda building and recording the film material for the panoramic display with this complex camera rack on an actual balloon ride, finally resulting in the Cinéorama display. Only through the 360° all-around motion picture, the feeling and illusion of leaving the ground was possible. The Cinéorama was the first to master the lift-off experience from the ground.¹³

It took more than 50 years to revive the concept of the Cinéorama. The Circarama, an 11 camera/projector system, was invented by Walt Disney and his company for his theme park Tomorrowland, and opened in 1955 with the 360° movie *A Tour of the West* (Pierce, 2012). The audience was taken on a car tour through the west.¹⁴ A reporter of that time described the experience as following: “Thus engulfed, the spectator is overwhelmed and involuntarily experiences the sensations of moving with the picture” (Pierce, 2012, p. 1). In 1967, the Circle-Vision 360°—a technically improved multi-camera/multi-projector 360° system, using only nine cameras/projectors (Lexikon der Filmbegriffe, 2012)—replaced the older Circarama in Disneyland’s New Tomorrowland, after running the film *Magic of the Rail* in 1964 for, EXPO 64 in Lausanne. The Swiss director and producer Ernst A. Heiniger shot the film together with technical adviser Ub

¹³ The lift-off also plays an important role in the Ovoid Theatre and the contemporary planetarium, which have the digital fulldome projection capacity.

¹⁴ <http://www.disneyhistoryinstitute.com/2012/07/old-tomorrowland-walt-disney-and.html>.

lwerks throughout Switzerland. The theatre was 26 m in diameter and could contain up to 1200 people for one show. It was a great success (Piccolin, 2004). Nevertheless, in 1997 the 360° theatre had to make way for a new attraction and was dismantled. From 1982 onwards, there were still several Circle-Vision 360 ° films to be seen inside special cinemas in Disney World.

1.1.6. The Swissorama

The Swissorama-system—another circular cinema by Heiniger—was installed in 1983 at the Museum of Transport and Communication in Lucerne, Switzerland. For the opening, Heiniger shot "Impressions of Switzerland," a 20 min touristic journey through Switzerland. Here also, the theme of transition, of being in motion through transport, was the main focus of Heiniger's early 360° movie material. In subsequent years, other themes such as hydraulic engineering, transportation technology, Swiss landscapes, and cultural sites were showcased.

1.1.7. The Ovoid Theatre

This lift-off moment is very special, and one that is being reused over and over again in contemporary digital planetariums. It is a bridging, a transitional shift, and a breaking point, opening up new frontiers that were for a long time unthinkable. It represents a moment in which the static safety of being on the ground is suddenly removed—an extraordinary experience of which one is reminded each time when a plane lifts off the ground. In the 360° space this moment can be very powerful.

The lift-off situation and its impact was also observed by Charles Eames, and re-created inside his Ovoid Theatre in the IBM Pavilion for the New York World's Fair in 1964 (Figure 1.17; Casati, [1965] 2012).



Figure 1.17. 1964–1965 New York World's Fair IBM Pavilion. Henry B. Comstock. 1964 In Popular Science, p.59

"The 1964-65 New York World's Fair IBM pavilion, designed by Charles Eames with Studio Saarinen, featured a suspended ovoid theatre over a canopy of steel trees, in which a multimedia show offered glimpses of the future" (Casati, 2012, n.p.).

The lift-off was realised through a real hydraulic lift, 53 feet high, which could carry up to 400 to 500 people straight from the lobby into the theatre. The theatre was placed above in an egg-shaped construction called the “Ovoid Theatre.” This hydraulic lift was configured like a grandstand and was referred to as the “People Wall.” Through the lifting, in a little under a minute one felt like leaving earth and being hoisted into another realm, here inside the core of the steel egg. For the inside of the theatre, Charles and Ray Eames developed the project *Think*—a multiscreen slide show. Within the round shape were placed 14 large and eight small screens of different shapes and sizes, on which animated, still, and live-action shots were projected (Eames Office, n.d.).¹⁵

The slideshow explored thematically the “problem-solving techniques for issues both commonplace and complex—from organizing the seating chart for a dinner party to city planning” (Eames Office, n.d., “Think”). For Charles and Ray Eames, the emcee in the entry hall was very important with regard to their guest/host relationship. He greeted the audience and, more interestingly, introduced in the theatre some of the more complicated sequences. In that function, he reminds me of the moderator and/or space pilot (see Chapter 2) in contemporary fulldome theatres. During a flight through the cosmos, often using the Digital Universe Atlas (DUA), there is always a knowledgeable moderator, who explains what can be seen in the 360° space.

¹⁵ <http://www.eamesoffice.com/the-work/think/>



Figure 1.18. The Ovoid Theatre from the inside. Source: Eames Office.com.¹⁶

Although the rounded structure was used to place as many screens as possible, the overall experience inside the Ovoid Theatre appeared fragmented—I suggest this was a limitation due to the available technology, which forced the artists to use several screens and projectors. A seamless 360° projection was difficult to realise at that time. Nevertheless, this installation shows that the Eameses were thinking ahead of their time, trying to escape the single flat screen of one source and thus taking a step forward into the all-around view to immerse the audience in moving images and multiple sources. Similar to the Dutch artist Stan Vanderbeek and his “Movie-Drome” (Sutton, 2003). McConville (2007) clarifies further that Vanderbeek understood the Movie-Drome as a prototype for

¹⁶ Retrieved from <http://www.eamesoffice.com/blog/eames-ovoid-theatre/>

“international audio-visual research centers” for the development of a “new non-verbal international picture language”(p.7). His new language was meant to encourage international dialogue and cultural understanding via the direct transmission of emotion. Vanderbeek further imagined a “real-time programmable communication network” that could “transmit and play back imagery from a world-wide library”(p.7)—a reality today in most fulldome planetariums.

The all-around view concept was also taken further inside planetariums—something that is often overlooked, since planetariums tend to escape the wider public eye, representing instead rather a niche market. In addition, animated visuals and movies were used inside various classic planetariums under the cupola. Sometimes several movies were projected simultaneously on the cupola through projectors. This also resulted in a fragmented 360° canvas. However, artists and producers working with planetariums tried to achieve a whole image coverage of the cupola. They thus complemented the all-around experience, which could be achieved with a combination of the starry sky through a star projector and still panoramas or still allskies covering the ceiling.¹⁷ With an all-sky, the zenith of the hemisphere could also be covered via slide-projectors. Thus planetariums and the industry around them took a lot of effort to further develop both the content and technology of the all-around view in order to push the inner space of the medium to further visual capacities (see Chapter 6 for more detailed information on new 360° formats).

¹⁷ Allskies are 360° images that cover the whole cupola ceiling, including the zenith.

1.1.8. Conclusion

Through the examination of historical concepts for immersive 360° media, such as the Globe of Gottorf (as the first planetarium), the Georama, the first Zeiss planetarium in Jena, panorama, the Cinéorama, the Swissorama, and the Ovoid Theatre, common features have been identified. In all concepts, the genesis and usage of the all-around view plays an important role, empowering and intensifying the visual effect for travel, lift-offs, or further perspectives and insights into natural phenomena—mostly in a transitional state.

Interestingly, in some of these historical concepts the cartographies of sky and earth have already been naturally joined together as, for example, inside the model of the Globe of Gottorf. Moreover, the passage function has been used in the sense of sky or earth rotations, as far as the technology would allow. Even hydraulic power was applied to lift a whole audience into an elevated theatre as a transitional experience and preparation for the visual environment inside the “Ovoid Theatre.” Another impressive 360° passage experience was accomplished with the Cinéorama, giving the illusion of rising from the earth’s surface above Tuileries Gardens in an all-around view.

Significantly striking is how much effort has been expended only to give an illusion of passing, of being in motion with a train, ship, or any other vehicle that was imaginable and accomplished in the 19th century motorised era. It is indicative of the human wish to be in motion, inside a transition as opposed to

the safe, static position of standing on the ground. In order to achieve this effect, no effort was spared.

In some of these concepts, scientific approaches, such as cartography, are merged with both engineering and artistic visualisation. The all-around view is empowering these concepts, intensifying the visual capacity through the 360° technique, thus pulling the audience into the visual space. Similarly, it gives the possibility to create passages via lift-offs or imaginary travel to exotic countries, as enabled by the Georama or even the Cinéorama, creating epistemic function in the process.

1.2. Seeing All with the Panorama

Introduction to the Panorama

“These paintings are faithful reproductions of what a place looks like when viewed from all angles and from as far as the eye can see.” – Bernard Comment (1999, p. 7)

Invented in 1788 and originally called “La Nature a Coup d’Oeil,” the term panorama was coined by *The Times* in 1792 (Comment, 1999). The term *panorama* refers to the Greek meaning to “see all” (Comment, 1999). From its birth until the present day, the panorama has remained a fascinating medium that embraces concepts such as the *Rundblick* (the circular view), and the

Übersicht (the gaze from above; Comment, 1999), resulting in an overview, a totality of the visual, embracing all angles and horizontal depth.

Oettermann (1980) declares that the panorama is symbolic of a “democratic perspective,” allowing multiple perspectives as opposed to Baroque theatres, which enabled only a single correct view for the royal class, sitting in the perfect frontal position. Conversely, the panorama offers room for 150 spectators in any chosen position of 360° visual space at the same time. Since traditional paintings often allowed only one perfect view point from which to enjoy the full micro cosmos of a framed visual, a spectator standing slightly sideways could already not experience the full potential depth of the painting. In comparison, panoramas stand for a collective experience, (Oettermann, 1980) I suggest as in contrast to a single person experience, such as the first-person perspective in cinematic language or in contemporary gaming environments.

Visual spherical interpretations currently seem to experience a revival through many diverse media formats, ranging from panoramic and fisheye photography to 360° video and VR full spherical environments. The panorama is a medium that reinforces a collective group experience, in which every visitor entering the panorama takes in the same circular, unified perspective of the world or a part of it. The world is being arranged around the visitor through a representation of a chosen metropolis at a given point in time. This collective experience is tremendously important, especially in a contemporary context, in which personal isolation is more prevalent than ever before. For example, we are increasingly separated by our individual mobile screens. The habit of watching

collectively the same television programme in the living room is fading. Further to this, watching the same programme individually, albeit at the same time, and thus being able to discuss it together the following day, seems to be a thing of the past. We are experiencing a time of radical change, a shift towards greater autonomy with an associated loss of the collective experience. For this reason alone, and irrespective of other tensioning factors, the concept of the panorama and its function as a collective visual unifying force is worthy of further exploration in this chapter.

1.2.1. Themes for the Panorama

Of particular interest here are the specific themes that appeared both worthy and valuable enough for artists to choose as the subjects for panoramic environments. I investigate which themes were regarded to perform well in 360° rotundas and what reasons were behind the landscapes finally chosen. Further, I investigate which functions and aims were put into the concepts of panoramas.

The first panoramas, such as “London from the Roof of the Albion Mills” by Robert Barker (1792), “View of Paris from the Tuileries” by Pierre Prevost (1799), or “Frankfurt am Main” by Johann Friedrich Morgenstern and Bernhard Hundeshagen (1811), were exactly representing the cities in which they were located. It might appear a bizarre duplication to showcase inside an enclosed environment the same surroundings that can be found outside the panorama. However, critical theorists imply that this circumstance was due in part to the Industrial Revolution, the rise of the metropolis, and the need and eagerness for

self-representation (e.g. Beyer, 2018). They also suggest that it was for the creators and everybody involved a chance to regain control over a growing collective space, growing in the sense of new cityscapes coming up and having more space to offer for visual, all-around interpretations of diverse surroundings (Comment, 1999). The success apparent by the rapidly growing number of audiences underpin the argument that national and local identity was sought after and could be satisfied by representing the nation through the medium of the panorama. It can also be suggested that it was an orientation tool in a time of unrest and significant social change.

A second theme was nourished by the desire to travel to foreign and exotic countries, which was only possible for very few wealthy families. These panoramas portrayed Rome, Florence, Naples, Palermo, Pompeii, Athens, and Constantinople. Imposing landscapes, such as Switzerland, Etna, and the Alps, were other chosen themes for panoramas. Further to these examples and possibly for overtly colonial and imperialistic motives, exotic places such as Calcutta and Rio de Janeiro were chosen, aimed to promote a specific image in the public mind (Comment, 1999, p. 8).

Whilst the specific political climate of the 19th century and the use of the panorama for overtly political reasons lie outside the scope of this thesis, I would like to spotlight a third theme that also has political undertones, namely that of war and military power, focussing mainly upon historical heroes and significant events to strengthen concepts of nationhood for states in difficult political situations. Good examples of this are the Polish Racławice Panorama

(1893) described in the previous subsection. In this context, it is important to note that the panorama was used successfully as a propaganda machine (Comment, 1999, p. 8). The panorama, with its innate ability to pull the audience towards a specific theme and envelop them in a specific time, had a significant and lasting effect on the visitors. In this way heroic moments were kept alive for a long time. Conversely, the impact of the metropolis-themed panoramas was relatively short-lived, as cityscapes were rapidly changing. Panoramas portraying a specific city could not be adjusted that easily, thus reducing their lifespan.

Today the medium of the panorama is being reinvented through the work of artist Yadegar Asisi. It is intriguing to contemplate how unlikely it would be today to use a panorama to duplicate a contemporary local cityscape. Asisi's themes are historical events in cities like ancient Rome, as in his panorama "ROM 312," or exotic, natural places, such as his panorama "Amazonia," which is 30 by 100 m in size. Further works include "Everest" and "Great Barrier Reef." Other themes seem to be chosen for their historical heyday or representation of delicate political changes, such as "Baroque Dresden," "The Wall," "Rouen 1431," "Luther 1517," "Dresden 1945," "Titanic," "Pergamon," and "Leipzig 1813" (see footnote 18). When asked how he chooses his themes, Asisi (2014) answered: "Whether I depict cityscapes or natural environments, I am inspired by the tensions arising between those two powers of creation—mankind and nature. For me, it is ultimately a question of the wide variety of genesis and decay"(from

an exhibition, translation mine).¹⁸ On his internet page, Asisi's panoramas are praised as being the world's biggest 360° panoramas, reaching a height of up to 32 m and a circumference of up to 110 m.¹⁹

1.2.2. Perceptions of the Panorama

There are several ways in which a panorama can be perceived, depending largely on the individual preferences of the viewer. I would like here to describe several aspects that demonstrate the strength of the medium. Firstly, the size of the rotunda building itself—and therefore that of the panorama—is very important, specifically the number of available floors from which to view the panorama: from above, from the mid-level, or from ground level. This affects directly the time needed for the viewer's sense of perception to reconstruct the whole surrounding environment in order to localise itself within the new coordinates of the circular landscape, thus enabling the viewer to perceive it in its totality. Once a schematic inner model of the environment is established, one can focus on specific areas of interest and complete one's inner map of the landscape.

Another approach can be to give the frontal ground of the panorama a specific distortion, which automatically pulls the visitor's gaze towards a specific line of sight, attributing further depth until the horizon is reached—for example a street, inviting the gaze to follow its path. The spectator is attributed significant

¹⁸ Retrieved July 21, 2016, from <http://www.asisi.de/en/yadegar-asisi/idea.html>.

¹⁹ Information retrieved from <http://www.asisi.de/homepage.html>.

autonomy, for instance in which direction to look or how to position oneself with regard to the canvas. The balustrades of the viewing platform impose the only limitation, which is necessary not only for safety reasons, but also to ensure that the distance between viewer and surface is optimised in order to view the panorama at the best possible resolution. Thus, from the viewing platform, the viewer can continue to place one's chosen perspective all the way around the 360° circled canvas and decide how much time to spend on each area. This can be repeated on each available floor level, thus offering multiple perspectives.

1.2.3. The Transition of Near and Far

It is interesting to note how some panoramas try to unify the distant and the proximate in one panorama. There are some panoramas that, when viewed close-up, do not include much detail and are thus only fully perceivable from a distance. Historically, panoramas had to follow some specific rules of artistic expression. For instance, they were meant to be just a reflection of the real: "The painter must not represent what actually exists but only its reflection" [Schlegel cited in Comment, 1999, p.111]. However, some panoramas—such as Thomas Hornor's "Panoramic View of London," displayed at the London Colosseum—include so much detail—even showing naturally hidden areas, for instance by smog—that when viewed through a magnifying glass, one could recognise even the smallest details, such as hair or tears (Comment, 1999).

Comment (1999) declares further that the distance allocates the relationship to the elements. The overview tends to immobilise individual elements, whereas

the close-up view is filled with life and detail, referring to the following quote by Blaise Pascal: “A town, a landscape are when seen from afar a town and a landscape; but as one gets nearer, there are houses, trees, tiles, leaves, grasses, ants, legs of ants and so on to infinity” (Pascal as quoted in Comment, 1999, p. 111). Sometimes the approach to add as much detail as possible is in conflict with the aerial perspective and is thus responsible for the panorama’s hyperrealism. I would suggest that, although the artists had the possibility to play with perspective and distortion—since objects could be illustrated close to the bottom as well as far away on the horizon, as seen in fisheye photography or as possible with the fisheye camera distortion options in 3D animation programs—this was rarely done.

All the panoramas in Comment’s (1999) book *The Panorama* are undistorted in the lower area. In other words, from the point of view of perspective, the lower portions appear to be at the same distance as the middle sections. Therefore, the angle of depth runs from the bottom to the horizon very steeply. This may have been due to the fact that panoramas were quite restricted: they were meant to depict the areas of focus in a very objective way and as realistically as possible precisely without exaggerated perspective distortion. The degree of objective realism was so high that some panoramas were regarded as the predecessors of photography (Comment, 1999). In more recent panorama work this objective restriction is overcome, as will be explained more fully in the following sections.

1.2.4. The Medium of the Panorama Today

Whilst some authors and artists still marvel at the secrets behind the panorama, there are others who feel the medium and its impact to be very much concluded, as can be seen in Max Brod's (2014) commentary on the Kaiserpanorama in his book *Von der Schönheit hässlicher Bilder* [On the Beauty of Detestable Images]:

"Poor panorama, the joy of our grandparents, relict of the Biedermeier era: today it is the cinema that makes our nerves tingle. We want to be dazzled by the dancing eyes that watch us from a chalky screen and not be staring, silent and calm, into a black box through a lorgnette" (pp. 59-67, translation mine).

For a long time, the panorama was considered obsolete—the mass medium of the 19th century—then cinema came and the panorama was not of interest anymore. Some people felt an enduring fondness for the panorama (Comment, 1999, p. 257) even during its absence, until the recreation of the panorama in 2016 by the artist Asisi, as mentioned in subsection 1.2.2.

In 2016, Asisi decided to reuse the rotunda shaped gasometer in Pforzheim, Germany, as a huge inner canvas for a panorama. He decided to use the old medium of the panorama on purpose. It can be seen as a revival of the 360° panorama format. Asisi created a panorama of Rome in the time of the Roman Empire, when ruled by Constantine the Great. The location of the artwork itself, the city of Pforzheim, was at that time called Portus, meaning the port to the

Roman trade network, situated between Ettlingen and Stuttgart. Thus there is a historical link between today's artwork and its location in history (Asisi, 2014).

What struck me most about Asisi's work was the question why somebody today would still use such an antiquated format such as the panorama—a still image. Why not at least a cinéorama, or a similar 360° cylindrical moving image? Is it a sign that in a contemporary digital and more dematerialised era, the desire for a more physical experience re-emerges? Although the inside of Asisi's gasometer is impressive because of its sheer size, measuring 40 m high by 40 m wide, the panorama itself is only a still image. With a carefully chosen soundscape around the cylindrical canvas and an imitation of a day and night cycle through the intensity of the light, the Rome panorama becomes more vivified. The effect of the environment is quite impressive, especially the high resolution and the very detailed realisation.

Asisi (2014) explains in an interview how, as an architect, his focus was always to create space. His main aim is to include the human into the planned space from the beginning, because a lot of contemporary architecture caters for transport, trade and finance, resulting in architecture that becomes more and more inhuman. Further to this, he believes that the human being is fundamentally a spatial creature and therefore exhibits a high necessity for spatial experiences. For him, a panorama of that size is an endless spatial experience, which can be reconfigured and expanded. Because all of the senses create space, he tries with his artwork to trigger them all—through sound, vibration of the hand rails, the contrast between dark and light, and the peripheral vision of the 360° visual

space. I suggest it is worth noting that further inputs such as smell or temperature are not engaged.

1.2.5. Comparison of Historical and Contemporary Panorama Creation

Historically, panorama artists studied the chosen environment quite carefully, taking sectional portraits, later using the camera obscura and photography to plot the terrain. Nevertheless, technical and compositional difficulties remained unresolved (Comment, 1999). It was quite difficult to translate flat drawings and their perspectives to a cylindrical environment, measuring up to 15 by 120 m. This meant that horizontals needed to be continually rearranged to balance for the multiplying of vanishing points and the distortion this involved (Comment, 1999).



Figure 1.19. A panoramic beach. Panorama Mesdag, painting by Hendrik Willem Mesdag, 1881.²⁰

Quite often the frame borders of the panorama, such as the bottom, were supposed to vanish in order to complete the illusion of being transported to a particular landscape as seen in figure 1.19. The artists thus blurred their panoramas with a fake terrain. This can be seen in Figure 1.20, which shows the viewing platform and the fake terrain with its beach paraphernalia. The distortion and perspective of the objects in the lower portions of the panorama

²⁰ Retrieved June 14, 2016, from [https://pl.wikipedia.org/wiki/Panorama_\(malarstwo\)](https://pl.wikipedia.org/wiki/Panorama_(malarstwo)).

had to be chosen carefully to match with the fake terrain from all possible viewing angles on the platform.



Figure 1.20. Beach paraphernalia: Chair, basket, and fishing net in foreground at the Panorama Mesdag. Photograph by nn.²¹

Today, the creation process of new panoramas by Asisi includes several activities that are familiar from the development of the old panoramas. One is to travel to a chosen city and to take photos from diverse angles. These photos, sometimes including landscapes, can also include smaller details, like a specific flower, a sunbathing cat, or something similar. All of this information is then re-assembled through photos, 3D modelling of missing architectural parts, and paintings. Asisi's Rome panorama is a bizarre montage, showing contemporary images of historical architecture with 20th-century men dressed in Romanesque clothes made from modern fabric.

I wonder whether keeping the architectural surrounding in black and white would not have helped to keep the distance, whilst preventing a confusion

²¹ Retrieved June, 14, 2016, from [https://de.wikipedia.org/wiki/Panorama_\(Kunst\)](https://de.wikipedia.org/wiki/Panorama_(Kunst)).

between the time periods. I remember looking through a book of Rome, which showed historical architecture in a contemporary setting, but with a coloured, transparent foil, one could cover the image and see how it must have looked in the past, including the sections now lost. I remember my fascination with it, partly due to its truthful handling of the subject. The black and white displays the contemporary architecture, whilst the overlay—made recognisable only as an add-on—conceptualises how it may have looked in the past. In this way the architecture of today became the architecture of the past, as with an old puppet coloured and covered with more details, trying to be a much younger version of itself, whilst beneath it remains as it was before, having seen so many centuries. In the process of trying to be something else, it loses its rich historical dignity of centuries past.

1.2.6. Motivations for Using the Panoramic Format Today

The question of why Asisi decided to use the panorama for his depiction of Rome and not a film or a large, flat canvas, remains unanswered. In one of his interviews, he describes his fascination with panoramas, specifically their ability to transport an audience inside the presented theme (Asisi, 2014). Through this process of transportation, the panorama can achieve an immense impact. This effect requires that the panorama enables one to see and experience a complex space, enfolding its presence through time. The viewer explores the landscape slowly. Inside Asisi's gasometer, visitors have the possibility to delve into the Rome panorama over five stories, because in the centre of the gasometer there is a staircase over five floors, each of them serving as an observation deck. The

layout of the stairs in the middle of the building is reminiscent of the staircases inside its historical predecessors, such as the Georama. Of course the main difference is that the Georama was not a cylinder or a rotunda, but had the sky, the ceiling, and the bottom covered—a full sphere.

As a painter, Asisi's aim was to create a space in which a specific, historical moment would be captured. He chose a city for its ability to demonstrate how people of the time were organised: in the architecture of a city, one can see the spirit of its time. Here the city of Rome appears militant, as is often the case with representations of the Roman Empire, or appears philosophical, as at the peak of the Greek civilisation. In a space such as the panorama, such a city can have a suggestive emotional impact, Asisi believes, transporting the visitors and even moving them to tears through an emotional touch of the 360° atmosphere.

1.2.7. Distortion and the Panorama in Asisi's Work

As already discussed, Asisi suggests that the panorama, as a 360 ° environment, has the innate ability to transport its viewers to a specific place and time. This process can be intensified through the use of distortion. In the fulldome production, Asisi purposefully decided to use a far larger viewing angle than the standard 180° of the fisheye setting. The moving image was at times finalised with up to 230°, thus encompassing much more of the ground or lower perspective of the environment. Asisi also explains how he used perspective distortion of the lower portions to achieve a higher depth of the presented space. Through the years, he learned to expand on the distortion and experiment with

it, until he reached the ultimate proportions of the envisioned landscape (Asisi, 2014).

Further, the artist sees each of his panoramas as a process that is continually changeable and expandable. Asisi also sees his art as a possibility to fill in the gaps left open by science. By using his imagination to capture the emotions and feelings of historical moments such as Emperor Constantine's invasion, he gives each visitor the experience of being an actual witness of a specific historical event (Asisi, 2014). I suggest that through these environments, Asisi creates an important experience that can answer many individual questions—answers unavailable through a text description, or a single image with one specific perspective, such as how it felt to live at that time, surrounded by such architecture.

1.2.8. A Comparison of the IDE and the Panorama

Every visitor entering the panorama or the IDE takes in the same circular, unified perspective of the world or a part of it, such as a chosen city at a given time—as is the case with the panorama. The actual image spread around 360° is the same for every visitor, but that visitor's perception of that image depends on the individual visitor's focus and the direction in which he or she chooses to look, on which parts he or she will concentrate, and therefor build his or her own meaningful construction of the story. Both media formats can therefore immerse a specific group of people into the same visual 360° experience.

Both the panoramic and IDE formats presented politicians with an instrument for propaganda: Both the panorama, which was used to communicate specific political, national positions, and the IDE—in the form of planetariums in the Cold War era—were used in this way, for example playing a major role in the communication of the race to the moon in the United States (McConville, 2007).

A further common factor appeared to me whilst studying the lithograph *View of the Observatory Erected over the Cross of St Paul's Cathedral* (1823) by Thomas Hornor (see Figure 1.21). I found this sketch immensely intriguing. It seems to give an account of how Hornor imagined his panorama would represent the London Cityscape. The landscape appears endless, only blocked in the zenith through the imagined panorama ceiling. It immediately reminded me of all the illustrations trying to explain how the IDE enables endless visual space in its hemispherical environment, overcoming the spherical canvas, which should only function as a visual membrane, transparent and strengthening the visual space. These illustrations try to reveal an open hemisphere with an open zenith to any content visualisation.

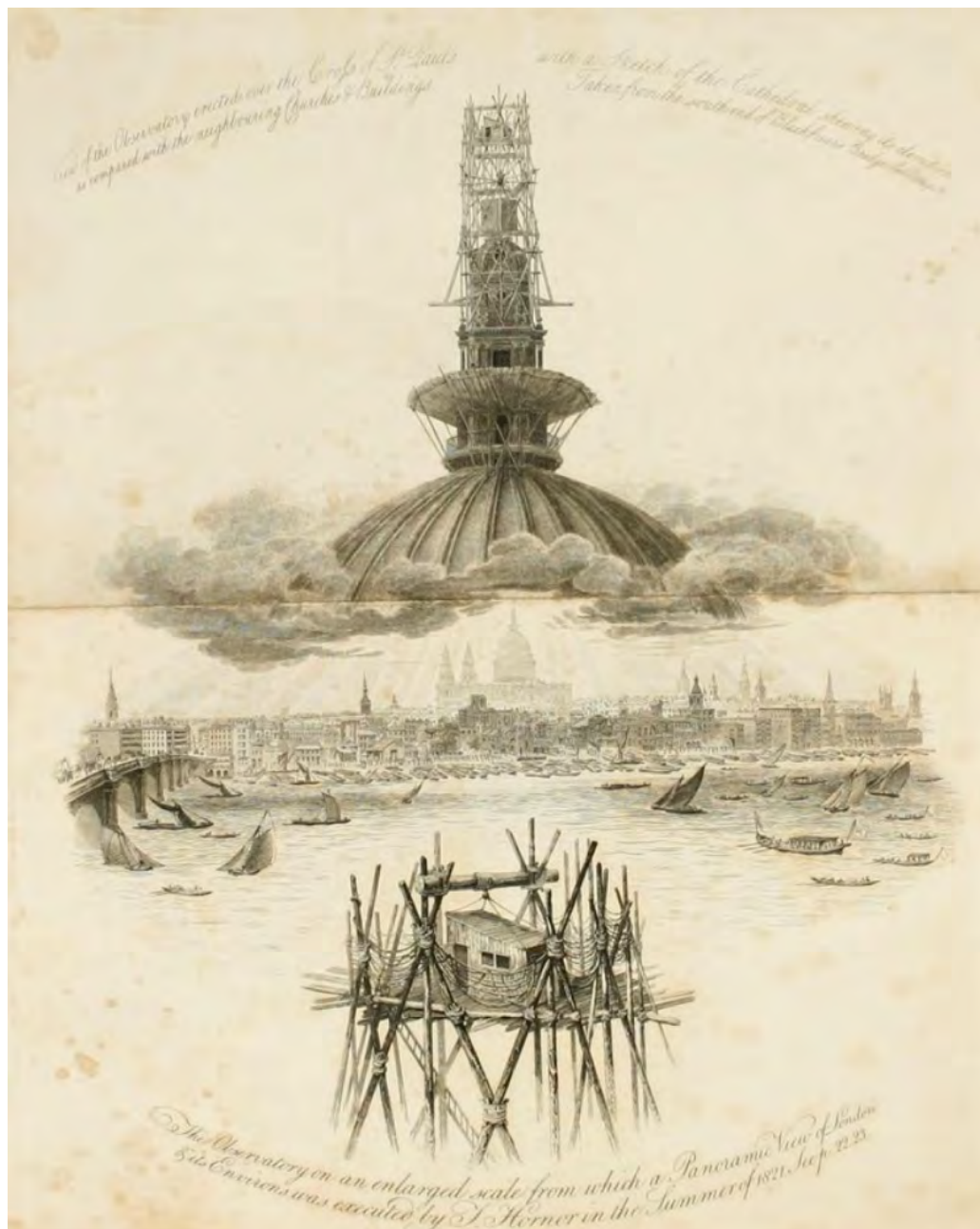


Figure 1.21. View of the Observatory Erected over the Cross of St Paul's Cathedral, lithograph by Thomas Hornor, 1823. In *Mirror*.²²

What is also quite charming about Hornor's lithograph is the panorama's reference to its place of birth—a wooden hut. This hut was Hornor's working place, whilst developing the all-around London panorama. Both the IDE and the panorama work with the spherical visual place, which enables them to work with

²² Retrieved from <http://longstreet.typepad.com/thesciencebookstore/2014/10/a-room-with-a-view-hornors-panorama-of-london-1821-and-its-cache-of-irony.html>

infinity. The panorama is limited to the range of the human eye, whereas the IDE is limited only by our current knowledge.

1.2.9. Conclusion: The Shared Transitional State of Spherical Media

All media such as paintings, panoramas, and cineramas, which have immersive characteristics, share a common goal, namely to transport their audience to another place and time. I would agree on this as one possible goal, but would like to suggest that often the aim was not to place the audience in one specific place, but rather in a transitional state, such as vehicles like ships, trains, and hot air balloons, allowing the viewer to be in-between places and/or in several locations simultaneously. Even the medium of the panorama developed sufficiently to allow unified hyper vision, including views from different locations—for example of a city—that could otherwise not be obtained. It can contain several locations, multiple perspectives, and vanishing points, all unified in one large-sized landscape or Cityscape. The panorama can also represent an in-between-state, between proximity and distance, depending on the richness of detail and the distortion from the horizon to the bottom. Whilst often critiqued, exactly this totality of vision makes the all-around format so unique, and when combined with passage transition, it could be the superior matrix for long-lasting experiences.

1.3. 360° (World) Creation Throughout the Centuries

This third and final subsection deals with the 360° creation process and specifically with the ways in which this process has been conditioned by technology, media, and changing perceptions throughout history. The term *creation process* refers to all the components needed to create a 360° visual space, from the first Zeiss planetarium to today's IDE. It includes everything from the initial production processes, ideas and concepts, to the final outcome, which can be a 360° still image, a 360° pre-rendered video, a collection of different interactive experiences under one dome, an interactive guided tour through an already existing 3D DUA, or an artistic piece that establishes new frontiers. One of the first books that deals with the history of the modern planetarium was written by Thomas W. Kraupe, entitled *Denn was innen, das ist draussen: Die Geschichte des modernen Planetariums* (What is inside is outside. The history of the modern planetarium), 2005 Director of the Planetarium Hamburg. I first read the book during 2006–2007, whilst working at the Planetarium as a 3D science visualizer. On the cover page, Kraupe quotes the well-known phrase "Nichts ist drinnen, nichts ist draussen. Denn was innen, das ist aussen"—"Nothing is inside, nothing is outside. Although what is inside, is also outside" by Johann Wolfgang von Goethe (Trunz, 1981, p. 358, translation mine). Kraupe references the quote, explaining that with the planetarium, we create a model of the cosmos that not only demonstrates the movements of the sky, but also gives the human a place in the cosmos. Further to this, he states that the sky unfolds not only above us, but also inside of us (Kraupe, 2005).

The concept of *inside - outside* with regard to the 360° medium is extremely complex and this complexity can be traced in the creation process throughout history. Therefore, in the following analysis this chapter will try to discover whether indeed it is a creation from the inside to the outside, or from the outside to the inside. I will seek to ascertain if the visual space is a limited one per se, restricted to the enclosing walls that serve as a display canvas, or whether it is a visual space that can even encompass the outside world. Are viewers outside or inside the world whilst participating in the visual content of 360° displays? Finally, I will ask how this relation between inside and outside has influenced the creation process of 360° environments, changing its concepts and ideas of content realisation throughout the centuries. In 1999, Comment realised that there is a certain paradoxical status already within the panoramic medium: it represents “an enclosed area open to a representation free of all worldly restrictions” (p. 8). Thus, it can be argued that the 360° visual space can be simultaneously enclosed *and* open. In order to chart a course through the history of the creation process for 360° media, I would like to start with the first Zeiss planetarium in Jena.

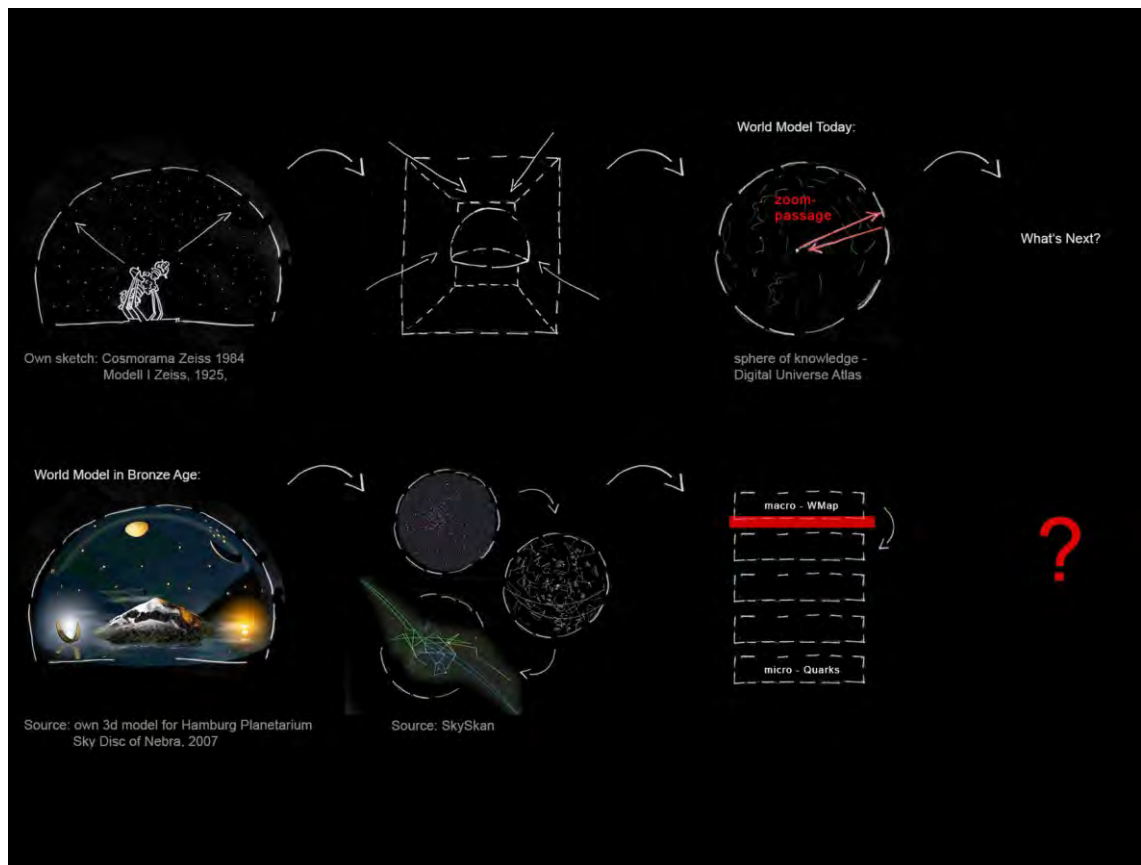


Figure 1.22. 360° Creation development. Sketches from my presentation at the Imersa Conference at i-DAT, Plymouth, England, February 2, 2015. Isabella Beyer

1.3.1. The First Zeiss Planetarium - From the Inside to the Outside

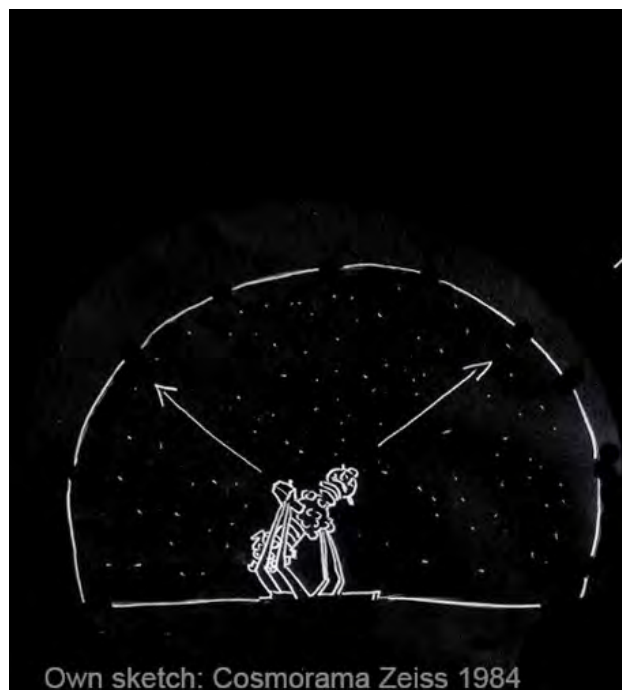


Figure 1.23. The creation process of the first planetarium shows. Sketches from my presentation at the Imersa Conference at i-DAT, Plymouth, England, Isabella Beyer, February 2, 2015

To achieve coverage of the whole dome hemisphere, the creator—in this case Bauersfeld and his assistant engineer Pulz—had to think from the inside of the planetarium to the outside of the cupola ceiling (see Figure 1.23). In the creation process, they had to solve how to project stars from the inside of the planetarium onto the dome's inner walls and whilst doing so, to come as close as possible to the appearance of the real starry sky outside. This concept was described by Bauersfeld in 1919:

"The great sphere shall be fixed; its inner white surface shall serve as the projection surface for many small projectors which shall be placed in the centre of the sphere. The reciprocal positions and motions of the little projectors shall be interconnected by suitable drive gears in such a manner that the little images of the heavenly bodies, thrown upon the fixed hemisphere, shall represent the stars visible to the naked eye, in position and in motion, just we are accustomed to see them in the natural clear sky." (cited in Marché, 2005, p. 13)

Thus, the aim was to move the heavenly bodies—or in other words, to put them in motion—and to make as many stars visible as would be possible to see from the earth in perfect weather conditions with no light pollution. This number, already with the Zeiss Model I, was 4500 stars (King & Millburn, 1978, p. 344).²³

²³ Werner, *Stars by Optical Projection*

With the classical star projector and the resultant fixation of the great sphere, it was, and remains, impossible to leave the earth and to look into the cosmos from a different location, such as from other planets in the solar system or from another galaxy. In other words, it could be said that the *creation process* of the starry sky at that time, limited by the technological projection onto the fixed great sphere, is in some sense analogous to the imagination people had in the Bronze Age. They believed the stars to be fixed on a glass bowl above them. Only in the first Zeiss planetarium, the stars from the Zeiss Model I are created through the light projection of only a 200 Watt tungsten-filament lamp (King & Millburn, 1978, p. 344), which passes through holes in a metal sheet and then falls upon the cupola's inner surface. The star projector was never produced to allow a lift-off experience, in the sense of leaving the ground and moving towards the stars. Rather, the star projection was constructed in such a way that was dictated by the shape of, and distance from, the dome's inner surface. The visitor's position was, and remains, fixed to the ground with only the possibility to look up and observe the stars at this particularly set distance. Via sky rotation, the visitor can observe the stars at this specific distance from various points around the earth. Further to this, with the Zeiss Model II, the southern hemisphere could also be experienced—as seen from Australia, for example.



Figure 1.24. My own 3D scenery of the Bronze Age worldview, analogous to the depiction on the “Sky Disc of Nebra.” View as shown in the dome at Arche Nebra, 2007.

Returning now to the Bronze Age worldview, I remember how intriguing it was for me to create a 360° animation—a fulldome production—at the Hamburg Planetarium in 2007. The theme was the Sky Disc of Nebra. The show was, and might still be, presented at the Arche Nebra visitor centre, the place where the Sky Disc of Nebra was found (see Figure 1.24). The concept of this particular animation sequence was threefold: Firstly, the creation of the Sky Disc was shown. Secondly, I wanted to present the world, including the earth and the sky, as realised through the imagination of the people of the Bronze Age. I wanted to reproduce exactly how they depicted their world imagination on the Sky Disc of Nebra, using all the details from the disc for my animation, such as the boat, stars, moon, and sun, adding an exemplary landscape, including a mountain and a glass bowl as the sky with the golden stars sticking to it. The glass bowl was arranged above the flat miniature landscape, symbolising the earth through a Bronze Age imagination. In the third part this Bronze Age worldview dissolved, transitioning to the known universe—with a spherical earth as we know today.

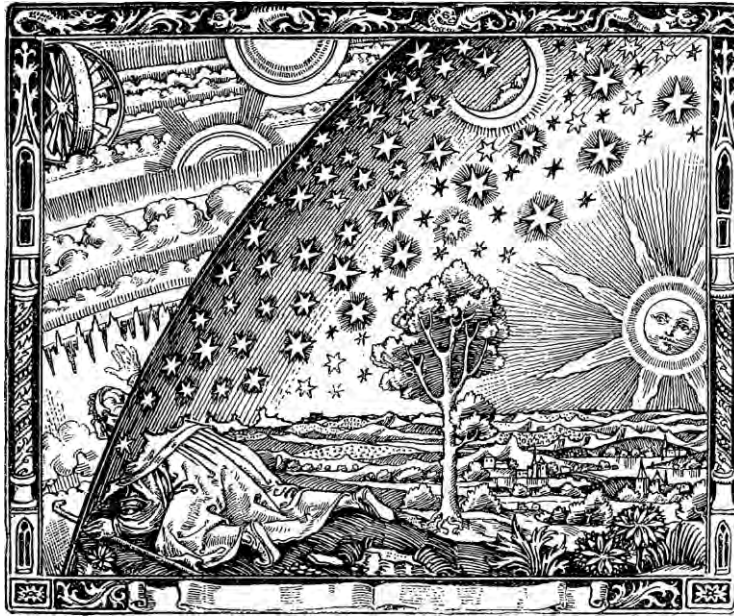


Figure 1.25. The search for the meeting point between heaven and earth. The Flammarion Engraving, artist unknown, n.d. First published in *L'Atmosphère: Météorologie Populaire* (p. 163), by Camille Flammarion, 1988, Paris.

The transition from one worldview to another is explained in the planetarium programme as occurring via the acquisition of knowledge throughout the centuries—associated with an advancing knowledge horizon (Figure 1.25). What was so intriguing for me during the creation process was its deeper meaning—it symbolised so much more. For instance, in some sense, it symbolised the liberation of the creation process under the cupola itself, from the restricted, projected starry sky of a planetarium star projector, to the digital planetarium, which can show nearly any content inside the 360° space, lifting the audience from the earth's surface and taking them to the borders of the known universe (for more on my work on the Sky Disc of Nebra, see subsection 5.2.5 of Chapter 5).

As described above, the display technology of the first mechanical Zeiss planetarium was restricted compared to a modern digital planetarium, however,

the concept behind the star device was far from limited. It was in many ways quite ahead of its time. Already in 1924, Wunder von Jena (The Wonder of Jena) with the Zeiss Model I, the main difference lay in the vision and concept of the projector device itself—namely not simply to create a still image of the sky, but to create a *space* that could be fully experienced, representing the night sky (Krause, 1993). In this respect many contemporary fulldome creations fail because they seek to create an image and simply cover the cupola with it, rather than creating a space (see also subsection 1.2 on the panorama and Asisi's aim to create space).

In view of the foregoing, it was remarkable that the German engineers at Zeiss were capable of creating a sky space that could be fully experienced—one in which the movement of the close celestial bodies, the planets of the solar system, matched with the starry sky of 4500 stars (King & Millburn, 1978, p. 344). The Zeiss Model II, with its distinct dumbbell shape, carries on each end a star projector, one for the northern and one for the southern hemisphere. In total, 4400 stars can be presented for each hemisphere (King & Millburn, 1978, p. 347). Even the time can be changed by years or decades, either to before or after the current date.

Even now, the starry sky projected through a high quality planetarium projector is impressive, leaving the audience feeling as if they have seen the real night sky in an observatory. The perception of blackness between the stars on a curved surface plays a significant part in creating this experience. The human sensorium cannot distinguish the distance between a flat black surface and the

eye. So the black space in between the points of light appears endless and thus the stars appear to shine somewhere in this blackness with no other depth information than their difference in brightness. This effect can also be experienced when one looks upon a white ceiling with only light patterns and no objects in-between. One cannot distinguish how far away the white ceiling is from one's eye.

In many books, articles, and essays (e.g. von Herrmann, 2018; King & Millburn, 1978), the experience inside the planetarium is described as a journey, passage, or travel. How could the experience of travel be induced through *only* a star projector, especially when all that the audiences could possibly see were stars and the blackness of the space in-between? This will be examined in the next paragraph by exploring an original programme guide from one of the first planetarium shows.

1.3.2. 3000 Kilometres per Hour - On the Wing Around the World

One of the first planetarium programmes in Jena, created in 1926, was called "3000 kilometres per hour - On the Wing Around the World." The programme was accompanied by a small booklet, which took the form of a tour guide. This booklet is still available today and as such represents a valuable contemporary resource, as it illustrates the concept of the first historic planetarium programme. It also gives additional information about the journey, such as the timeframe and an additional description of each stop.

This planetarium programme exceeded all expectations, the concept being far ahead of any other classical planetarium shows of the time (see Figure 1.26).

The show was surprisingly modern, setting as it did, the narrative in the context of a coherent journey from pole to pole around the earth, using all the possibilities of the new Zeiss star projector Model II.

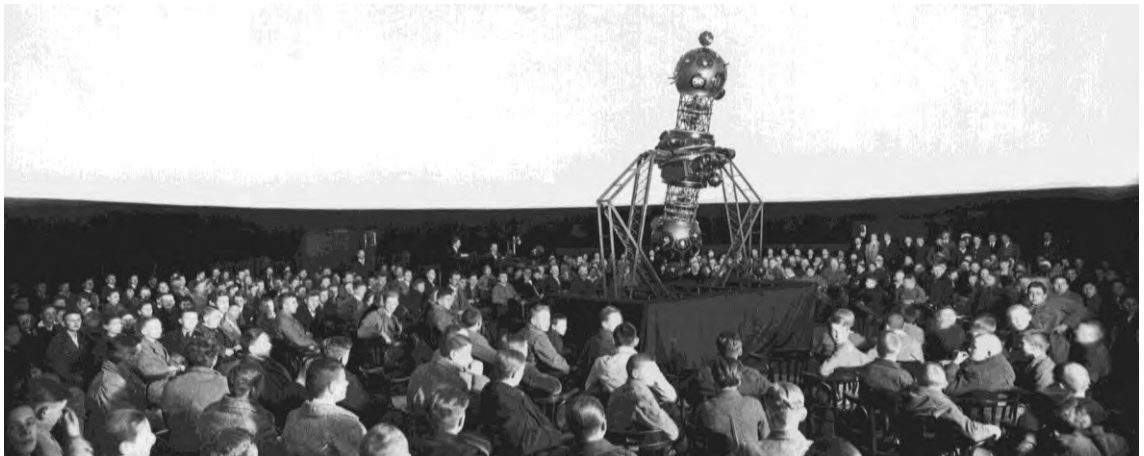


Figure 1.26. First school show at the Jena Planetarium, Zeiss Model II, 1926. © Carl Zeiss AG

As previously stated, in contrast to the Zeiss Model I, the Zeiss Model II could also simulate the southern sky. This new feature is emphasised in the programme, and was an important feature of the show: “Global trotter report to us, how difficult it was for them to orientate themselves on the southern sky. . . . Orion . . . stood on his head and was seen at a hot summer night etc. . . . an inverted world!” (n.n., 1926, translation mine).²⁴ In this way, the show makers tried to raise interest in the southern hemisphere and its star chart. The visitor was thus

²⁴ German original: “*Weltenbummler berichten uns, wie schwer es ihnen gefallen ist, sich am Himmel des Südens zurecht zu finden. . . . Orion . . . stand Kopf und war in heißer Sommernacht sichtbar usw. . . . eine verkehrte Welt!*” “3000 Kilometer in der Stunde – im Fluge um die Erde, „3000 kilometre in an hour – On the Fly around earth” own translation, original programme guide of the first Zeiss planetarium in Jena, 1926

able to identify as a global traveller, one who not only needs to know their geographic maps, but star charts as well—as a globetrotter, one needs to know the sky in both the northern and southern hemisphere to be able to find one's way. Thus, the traveller was invited to a one-hour journey around the world, made possible by the *Himmelsdom* [heaven's dome], inside which days can be experienced as minutes. At the programme's conclusion, the traveller returns to Jena and is presented with a forecast into the coming years and decades of the starry sky. The programme guide reaffirms that this is made possible because entire years elapse in mere minutes and seconds under the dome, presumably I suggest creating the notion of being in a time machine.

The programme was divided into three acts: In the first act, the journey starts from Jena, explaining the sky at home during both day and night. Then, the 12 constellations are presented, as well as the star Polaris, to indicate the North (N). Further, the two asterism indicating the warm and cold seasons are shown—the Summer Triangle and Orion at midnight (pp. 4–10, Jena programme booklet, 1926). In the second act, the journey progresses towards the North Pole, then to the heart of Equatorial Africa, Cape Town, the South Pole, and Australasia, finally through a meteor shower and then back to Jena. Africa and the southern night sky play an important role (pp. 10–22, Jena programme booklet, 1926). Finally, in the third act, we are located back in Jena, five days after setting out, since this was the duration of our journey. The starry sky stands still. Then years pass in minutes and the solar system comes alive. After four weeks the moon has orbited the earth and is to be seen in the sky. Mercury closes his round dance around the sun already after a quarter of the year. For

Venus and Mars, we need the whole year to see their encounter with the sun in the sky. Thirty years, nearly a human lifetime, have passed. Jupiter has three times and Saturn has once circled the heavens. We move 30 years into the future, yet to precisely the same date and time. The earth tumbles further. In three decades, the celestial clock shifts notably to the stars. The precession of the earth in the coming 26,000 years is presented. Finally, the old and familiar image of the sky is presented and the audience is being brought back to reality—often by slowly lightning up the planetarium theatre room, as it is common still today (p. 22, 1926).

In summary, throughout the whole programme the audience could only see the starry sky, no ground and no landscapes. The location on earth in the northern, or later in the southern hemisphere, could be travelled through the rotation of the starry sky by the star projector. Inside that *transitional state*, whilst rotating the sky and therefore travelling to other locations, the visitor could only see the movement, the slow rotation of the starry sky. It was the same technical realisation as inside the first planetarium, and the geocentric perspective had to be taken into the account, resulting in the impression that “*Der Himmel kreiste um den Besucher*” [“The sky rotated around the visitor”] (Kraupe, 2005, p. 25, translation mine). The visitor’s imagination had to complement the experience by imagining the matching ground of a particular cityscape or landscape. Therefore, the planetary simulation was quite challenging for the imagination of the audiences, since they had to complete the motion of the sky and re-orientate themselves on earth.

The entire three-act programme took an hour. Even today, German speaking programmes seem to ground themselves in this timeframe with programmes lasting for an hour, or at the very least, 45 min. For English speaking presentations, 20 to 30 min programmes are more common.

1.3.3. From the Classic Planetarium to a Splintered Visual Space

In the period from 1926 to 1960, the classical planetarium setting was common, the main attraction being the star projector at its centre. Most of them showed programmes based on Zeiss instrumentation. However, with the rapid accumulation of astronomical discoveries during that period, many planetariums seemed as if they were trying to explain the ocean whilst having only a pond at their disposal (King & Millburn, 1978). However, this situation was soon to change.

The Russian launch of Sputnik I, in conjunction with the International Geophysical Year in 1957, initiated what is now commonly known as the “Space Race” (Kraupe, 2005; McConville, 2007). Politicians channelled grants into the promotion of space, to the benefit of planetariums both in the US and the Eastern Bloc. Planetariums grew and evolved in both number and popularity in these areas, but most importantly their content also changed and with it the planetarium itself. Planetariums evolved to make it possible to experience the space destinations of the astronauts, no longer only showing the traditional programmes of the local sky. In this way, they developed further into space theatres (Kraupe, 2005, p. 62).

With rising funds, the planetariums requested wider display possibilities—a call that the manufacturers eagerly followed. Companies such as Sky-Skan, Inc.—founded in 1967 by John Paris, a former planetarium manager of the Strasenburgh Planetarium in Rochester, New York—manufactured special effect projectors, which were sold to planetariums worldwide.²⁵ From 1985 onwards, Sky-Skan, Inc. was led by Steve Savage and under his leadership further multimedia control systems, such as the “Spice Automation System” for planetariums, were developed.¹ Further control units were built into the “Spice Automation System,” which allowed control by only a single PC of audio, video, Dias, effect projectors, motors, and lamps (Smith, Sky-Skan brochure online²⁶). The planetarium in effect became a multimedia theatre. During this time additional star projectors from other companies also came onto the market (King & Millburn, 1978).

It is interesting to note how many different media forms were already in use at that time, all combined and mixed with each other to fill this immense 360° canvas. Slide-projectors, for instance, were installed in order to project whole panoramas on to the cupola. Additional slide-projectors were projecting still images of the newest, astronomical discoveries. Video projectors were displaying film sequences of launching rockets, for instance. All of these visuals were accompanied by sound and lighting effects.

²⁵ See <https://www.skyskan.com>.

²⁶ Retrieved from http://media.definitetheaters.com/files/brochures/Sky-Skan_Corporate_Brochure.pdf

Although panoramas were often used together with a star projector to cover the open dome ceiling with stars, soon other environments began to be projected into the full sphere, such as historical buildings or landscapes. The need for displaying a full sky remains most apparent in the planetarium setting. Thus, it seems quite natural that further media formats were developed, for instance the allskies, which can be seen as a further development of the panorama—a still image, but also covering the zenith.²⁷ To produce allskies, the team had to tour around the globe to find unusual landscapes, taking high resolution photographs with a fisheye lens.

1.3.4. The 360° Surface: Division vs. Continuous Space

As more media became available to the classic planetarium, the visual firmament became increasingly fragmented, and in some planetariums the visual experience took on a bizarre, mosaic-like appearance. At best these programmes became reminiscent of the Ovoid Theatre by Charles Eames from 1964. Often the overuse of media had a strangely unsettling effect on the observer. Images, presentation slides, panoramas, and videos appeared unorganised and disproportional on the curved canvas—the coherent visual 360° space lost or performed only for short intervals in-between with the star projector. An unsatisfying, splintered visual space was the result, far removed from the continuous space experience that characterised the first planetarium programmes described above. The combination of star projector and small

²⁷ A young group of students in Kiel founded a company around 1996 to produce photographic material as allskies. Today, the company can be still found under the name allsky.de (see <http://www.allsky.de>).

rectangular video footage on the big 360° screen made apparent just how much the cinema or rectangular, flat-image medium differs in shape and size from the 360° medium, and consequently, how unnatural it appears within it. (Own production observation) I remember a spectator's reaction in 2009 at the premiere of my movie "Touching the Edge of the Universe" at the Berlin Planetarium, which at the time was still optical-mechanical. The launching of the Ariane rocket could only be shown by a film through a video projector. He was disappointed and asked me why the rocket would not launch properly, going around the cupola and thus appearing much larger.

Even with limited means, such as a star projector and slide projectors, some planetarium staff still tried to achieve consistent and coherent visual experiences. Interestingly, mixed forms of display were developed. For instance, the usual rectangular video shape could be eliminated with a keying mask, so that a video of an astronomical event could appear seamless in the night sky. A further common technique—based upon the use of a wooden or steel silhouette of a city panorama around the dome's surface—was to project the cityscape at night around the cupola and to use the star projector to show the stars as seen from that city, so as to illustrate its particular view of the starry sky.

In order to achieve such a display, landscapes were projected through slide projectors as panoramas around the cupola's horizontal base-line and combined simultaneously with the starry sky of the planetarium projector. Early limitations meant that sometimes the stars overlapped the landscape panorama, because neither could the star projector be moved, nor the stars

trimmed out differently. However, as expertise grew, the panorama faded out before the stars reached their full brightness and thus achieved a more fluid transition. Some of these transitions I had to plan with Friedger Lachmann, the former production manager at the Berlin Planetarium, because the show “Touching the Edge of the Universe” was not sold only to digital planetariums, but also had to be prepared for opto-mechanical planetariums, which had various different sets of media and sound systems, all without any uniform standard.

1.3.5. Moving Beyond the Geocentric Worldview

Common and often realised transitions inside optical-mechanical planetariums were the day and night cycles. Generally, these either tended to be applied at the beginning of a programme to draw the audience into the darkness and to set the stage for the slow appearance of the starry night sky, or at the end, to bring the audience slowly back to daily reality (own production experience and observation).

It can also be suggested as a historical transition from the early days of the first planetarium programmes. These transitions were simulated most often through light, and sometimes through sound and the star projector itself. This linked control of lights, sound system, and star projector is still being used today in the digital planetarium, as a tool with which to introduce and stage the starry sky in an appropriate manner. However, even today these fluid transitions need good programming work and careful attention to detail, as in some of the digital

planetariums, a star projector is still being engaged as an additional—albeit separate—tool. Especially in domes larger than 20 m in diameter, the star projector is still being employed. Such combinations of digital and opto-mechanical tools are referred to as hybrid systems.²⁸ The most successful was certainly the Hayden Planetarium, which opened in the year 2000 and attracted 1000,000 visitors in its inaugural year (Kraupe, 2005, p. 99).

The star projector instrument has consistently improved and developed throughout the decades. Today one can read on the Zeiss internet page that the newest star projector, the Universarium IX, can project up to 9200 stars²⁹, each star having its own optical fibre, thus appearing ultra-sharp on the dome's surface. Its resolution far exceeds that of a digitally projected star field, which is always limited to the projector's pixel density. Additionally, the brightness and colour of each star is matched whilst even star scintillation is emulated. The starball³⁰ is equipped with all the projectors for the starry sky, plus additional projectors for the sun, moon, and planets, which can be individually implemented for didactical applications. However, of greater importance is how, for the first time, with a star projector it is possible to depart from a fixed geocentric view. The geocentric view—seeing the stars only from the earth's perspective—can be traced back to the geocentric and Copernican heliocentric

²⁸ See: https://www.zeiss.com/content/dam/planetariums/downloads/PDF/SKYMASTER-VELVET_I_EN.pdf

²⁹ Information from <https://www.zeiss.de/planetariums/produkte/products/universarium-modell-ix.html>

³⁰ The starball is the projection head that sits atop the projector mechanism in the middle of the planetarium (as seen in Figure 1.25).

worldview and the history of cosmology. It is also referenced and illustrated in my discussion of the Bronze Age worldview in section 1.3.3.

Today, with the new Zeiss star projector, it is possible to see the stars from different observer locations in the solar system in addition to the geocentric perspective, including spatial flight perspectives. This means that the fixed, geocentric perspective can be left and shifted to a number of other locations in the solar system. With the new instrument, it is also possible to jump up to 10,000 years forward and backwards in time with astronomical accuracy as stated by the Carl Zeiss AG. In August 2016, the Berlin Planetarium celebrated its re-opening with a new fulldome system and the Universarium IX star projector, illustrating how, even in a contemporary context, hybrid systems are still being installed.³¹

1.4. From the Outside to the Inside: The Digital Planetarium

Now, with the possibility of digital fulldome projection, opportunities for the creation process are set to expand in many directions. The earth can now be left and we can start to build from the outside to the inside.

³¹ I was invited to the opening event and could experience the system in action. Information about the installment can be found here: <https://www.zeiss.de/planetariums/installationen/deutschland.html>

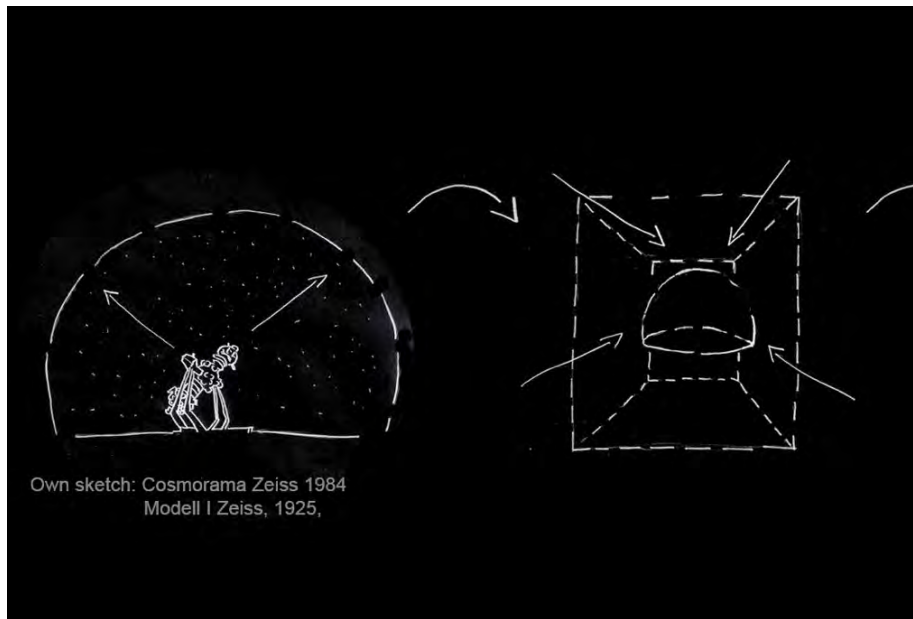


Figure 1.27. From the inside to the outside – 360° production. Sketches from my presentation at the Imersa Conference at i-DAT, Plymouth, England, February 2, 2015.

The world exhibition in 1900 came close to creating one space by lifting the audiences up into the Cinerama—a shared moment of elevation. Now, through the digital planetarium, the lift-off moment is realisable at any time and from any location, including both sky and earth visualisations. Inside the planetarium the audience can be lifted-up and taken out to any desired distance in the virtual known cosmos. The lift-off experience is quite crucial in this context: not only does it symbolise the liberation of content under the cupola, but also the virtual lift-off of the audience in the planetarium into the universe, leaving the 2D visual arrangement to enter the third dimension (Kraupe, 2005). The planetarium itself has thus changed its form from a fixed, rotating star instrument with a 2D image covering the inside of the dome, to a space flight simulator. The beginning of real-time touring through the universe within the DUA and various software packages for planetariums are now possible.

1.4.1. Unifying of Inside and Outside

In the following subsections, I address several functions of the 360° environment touched upon throughout this chapter that can now be further developed with the aid of new technology. In the ideal contemporary creation process, the creator or artist is thinking of the inside and outside simultaneously so that both views merge and are thus unified. The artist, whilst creating a partial 3D world for a scene, an own biotope, can see that biotope from the outside as a whole and from any other perspective, since the model can be rotated in the viewport and scaled in and out. Additionally, the creator has to pre-imagine how the fisheye camera will be moved through it. Since the full spherical image of that biotope appears around the audience in the dome, the artist has already in mind how the audience in the theatre will be moved through the scene, for example by the camera's path. In some sense, it could be regarded as fully empowering the artist, as he or she creates the world that the viewer will experience and decides how the viewer will move through it. This can be done in a much more intensive way than the cinema could ever do, because there are fewer constraints, such as with the rectangular film or video frame. The viewer in the fulldome theatre is immersed inside that world and cannot disengage from it, unless by closing one's eyes. Part of a 3D world is created through which, once complete, a camera path is planned and built. The camera then traverses that path whilst rendering images at 30 or 60 frames per second. The artist, seeing how the camera moves along the path, can simultaneously check the rendered preview as seen on the dome.

In this way, the creator is simultaneously looking from the outside onto the world model of the scene, and through the rendered preview from the inside of the dome onto the outside world, thus seeing how the world presents itself through the fisheye camera lens inside the dome.

1.4.2. Truthful Creation Process

Moreover, through the 360° hemispherical view, the creation process itself is more truthful. For a rectangular frame it is much easier to add 2D effects in the composition process on planar layers than is the case for the 360° hemispherical image. Additionally, the 3D world must be much more complete to fill the 360° view. In each direction, the viewer needs to see sufficient parts of the created world. The world therefore needs to be in, and of, itself more complete.

1.4.3. VR vs. Dome: Convergence in the Creation Process

Applications for the 360°-medium are developing fast, influenced by technology in other fields and the pace of change is ever-increasing. One of the most promising and prominent contemporary technologies is Virtual Reality, in combination with VR glasses. Although VR headsets have a long history dating back to the 1960s, only in recent years have they become affordable. At every media conference or fair at least one pair of VR glasses is a must and the topic of VR is very present. The following paragraphs will examine how important this format is for fulldome production, and how it influences the creation process in the field today.

Full dome producer Paul Morrow, Director of animation studios NSC Creative at the National Space Centre in the UK, stated in his presentation at the Imersa Conference 2015 that his studio uses the Oculus Rift for previews of the full dome content they create. With the Rift glasses, they test the immersive effect of the dome without going into the dome (Imersa Summit, 2015). When one looks closer at the creation process described at the beginning of this chapter and the contemporary use of VR glasses in the modern creation process, the glasses can be seen to have a tremendous effect on the finished work. In the modern creation process, the two views inside and outside coalesce, but the artist adapts the scene accordingly to the previews. If the previews are only seen in VR, for example through the Rift glasses, the inside view is quite a personal experience, the environment appearing closer than in the dome. In our productions, the preview process was taking place in the dome, so that all the other artists could also make suggestions to improve the visual. Therefore, through the use of the VR glasses, the creation process becomes even more isolated, but maybe aiding both concentration and creative flow.

Some content is, in addition to the full dome format, also produced for the Oculus Rift, specifically to expand the market. This procedure determines in part the choice of content—which has to work for both media formats. Therefore, an important interleaving occurs between the two media forms in the creation process. When content is being produced for full dome, it is only a hemispherical image and thus cannot be converted directly to VR, because a full sphere image is needed. Therefore, the lower hemisphere also needs to be rendered. This

requirement again changes the whole scene arrangement and camera motion. Everything in the lower portion therefore needs to be reconsidered.

In addition, the storytelling changes. In one scene of my film “Descent to the Deep” (Buczek, 2007) I planned a scene in the deep, below 1000 m, where no sunlight can penetrate and there is only darkness, with the appearance of a bioluminescent squid. It was to swim up behind the audience. In a spiral movement, whilst the audience is sinking, the squid will observe them and vanish towards the zenith. In the dome this scene works quite well, and a few people in the audience even turned their head in order to encounter this moment of surprise. If this scene would be recreated for the VR environment, the sudden appearance of the squid would be not possible in the same way. In a full sphere, one would see the squid already from the bottom. One could play with soft focus and depth blur under the water in the darkness—the further away the object is, the less it tends to be visible. However, the sudden appearance of an object that is already close would no longer be possible.

The other way around, the results are more promising. If we take a scene that is already complete for the fulldome view, for instance a flight over the Baltic Coast, and we render it in full 360°, the creator then would have the freedom to take any angle of view for the fulldome format. Even more interesting, the creator could adapt the compression accordingly, making it possible to add more visual information to the lower portion in the same format image, by not only taking 180° to the bottom, but up to 230° or more, thus compressing it in a

similar way as Assisi uses it in his panoramas to achieve more depth in his environments.

1.4.4. Additional Zenith and Bottom Area

How important is the zenith, if we compare it with the panoramic format? In the panorama this segment is missing, as opposed to the hemispherical fulldome format. Imagine we walk into the panorama through Times Square in New York and try not to look up. Or we try to admire the night sky, with the top missing. The full hemisphere gives us a good orientation and enough visual information to localise ourselves in the virtual 3D space.

With VR, we gain the whole lower hemisphere. The question arises whether this is actually needed, or how this shapes the experience. The act of wearing the VR glasses and therefore separating oneself from the real environment as well as from other spectators makes it a quite personal, individual experience. Because of the additional lower hemisphere, particular experiences such as flying, swimming, sinking, or floating in space, for example, could be designed quite intensively, so that the experience would be memorable in the long term. Of course this would depend on the visual detail and design of the environment, the introduction, and the process of slowly leading into the experience.

1.4.5. Conclusion: Different Outcomes of the Creation Process

Being within a spherical environment itself always implies a state of being between inside and outside: "We are in an outside that carries inner worlds."

[Sloterdijk cited in Schinkel, Noordegraaf-Eelens, 2011, p.14] Maybe this is one reason why the medium as such attracts so many creative people today who want to experiment with the format and thus break with established and rigid visual expressions. For the representation of inner worlds, various applications have been developed further. The 360° format has enabled and motivated all sorts of visual representation through the transition of time. It is a medium like no other, embracing many different concepts and technologies, unifying them and forming new applications.

Most programmes interweave narratives in documentary style or mix them with first-person perspectives and artistic expressions, or even through character play. Some digital planetariums that want to be more than mere playback cinemas in 360° are taking their commission of science communication quite seriously and thus want to use an especially active, moderating style. This flows back to the historical roots of the first Zeiss planetarium, which allowed the real-time steering of the sky. Thus, contemporary digital planetariums use hybrid systems to operate in real-time and fly the audience through, for example, a 3D DUA. Visitors are asked to choose their destination whilst the moderator becomes a space pilot and takes them to their desired destination in the cosmos. These interactive guided tours through an already existing 3D DUA have become quite common. Different software packages, such as Uniview (SCISS), SkyExplorer (RSA Cosmos), and SkySkan enable the touring and navigating through the complex 3D DUA in real-time. Additionally, the efforts of different institutions to develop the DUA further are producing promising results.

Through interviews with experts at the Imersa Conference 2015, it became apparent that there are exciting efforts heading in the direction of making the DUA dynamic, or in other words in sync with the real outside space. Pulsars are created to be in synchronous motion inside the DUA. The most recent images of Pluto's textured surface, taken by the New Horizons mission, are presented in sync, whilst travelling through the DUA to Pluto (Emmart, 2015). It is intriguing that the concept of synchronising the inside of a 360° inner canvas with the actual outside world has such historical echoes. Already with the Globe of Gottorf, the creators had the idea of showing inside the globe the same rotating starry sky in sync with the sky outside, which they planned to realise through the enormous axis and water power under the basement. Moreover, different applications of interactivity combined with artistic concepts in the dome are establishing new frontiers and whilst doing so, changing the transformation of the medium as such. The digital dome will continue to inspire new ideas as well as the realisation of various experiences. The initial pond of display tools slowly shifts towards an ocean of different visual tools of expression for the fulldome creators.

2. Le Passage: The Concept and Model

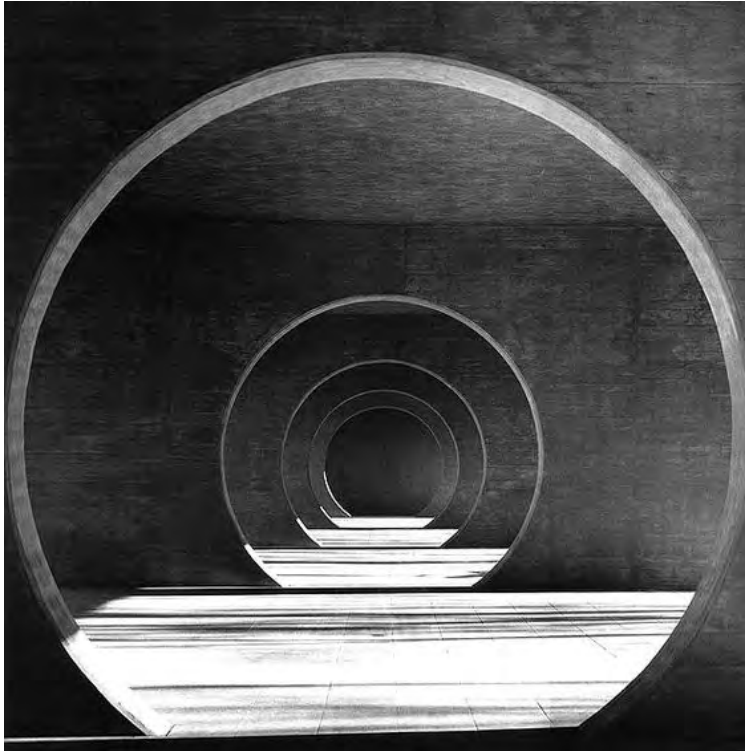


Figure 2.1. Architectural example of a passage concept. Housing complex in Novazzano, Switzerland, designed by Mario Botta, 1990–1992. Photograph by Mario Botta, © Daco-Verlag.¹

2.1. Introduction to the Passage Concept

In Chapter 1, the elements of movement, transition, and passage have been identified as vital characteristics of 360° environments and experiences. *Le passage* has a transitional function and is the core concept of this dissertation. In this chapter, the transitional effectiveness and individual characteristics of

¹ Retrieved June 14, 2016, from <http://scandinaviancollectors.com/post/151676255120/mario-botta-housing-complex-in-novazzano>.

various passage experiences will be examined through diverse, yet cognate disciplines and fields of study, such as literature, architecture (as seen in Figure 2.1), cinema, performative cartography, and geographical visualisation, using scale, zoom, or other passages. The aim is to collate the different aspects of these passage concepts in order to build a taxonomy and thus enrich the passage concept as such. An important property of the passage is that it should be a transitional state that can be enacted or realised through media, and can ideally be constructed inside the 360° medium.

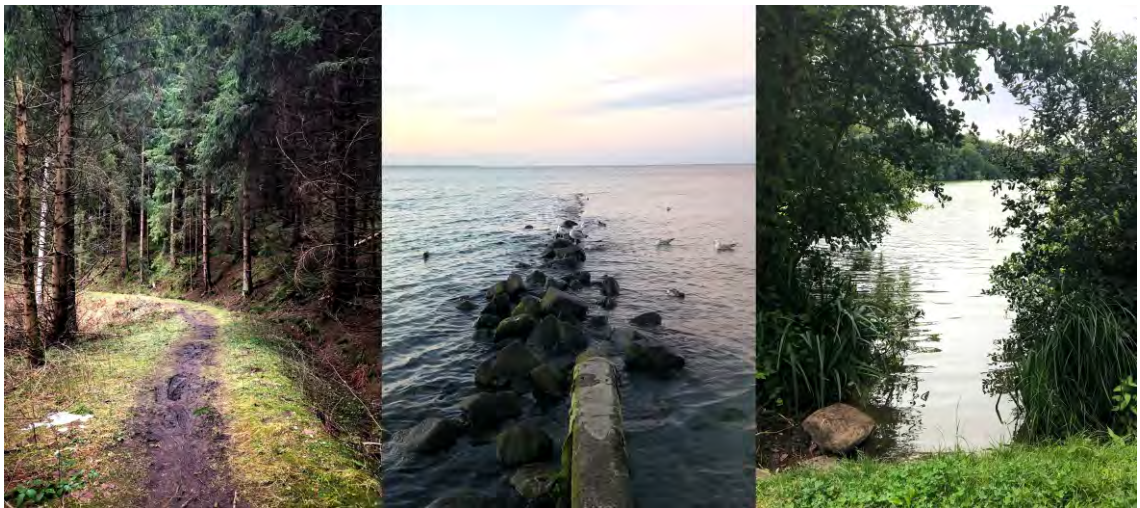


Figure 2.2. Passages in Nature. Photograph by Isabella Beyer, 2017

The chapter will examine the experience of a passage as a transitional mechanism that allows one to enter a new mode of perception. A passage should function to heighten our senses and thus raise our level of awareness, making the experience that follows both fuller and more intense. Already in the heyday of the panorama, this factor was acknowledged and integrated into the concepts. For example, dark corridors were created to gradually separate visitors from the outside world. Through a process of sensorial neutralisation, the aim was to

prepare them to embrace the new, encompassing world as they ventured deeper into the 360° panorama (Verhoeff, 2012).

In the moment of passage something crucial occurs—a transition—in which we change from a person A to a person B. We move from being inside an environment to being outside that environment, but then we find ourselves immediately inside another. It happens continuously, whilst watching a film change from scene to scene, and from one person's perspective to the next, or—if in the real world—through our own movement from inside a room to the outside world, or even when meeting a person and thus venturing into their personal cosmos. As a further example, in an educational context there can be profound effects when, after a period away, upon re-entering the study or lecture room one can sometimes suddenly see thematic connections that were previously hidden. These transitional experiences differ in their intensity and effect. We are in fact mostly unaware of these moments in all their varying intensities, in our lives as well as in the media that surround us.

Over time, and with developments in technology, the opportunities for media-based passage experiences has grown significantly—especially when one thinks of the audience's reaction to the first animated image projections, such as during the launch of the Cinématographe to a paying audience in December 30, 1895, Lyon, France (Toulet, 1995). As one spectator recalls, for just

a few minutes, a stationary photograph showing the Place Bellecour in Lyons was projected. A little surprised, I scarcely had time to say to my

neighbour: “Have we just been brought here to see projections? I’ve been doing them for ten years.” No sooner had I stopped speaking when a horse pulling a cart started to walk towards us, followed by other vehicles, then passersby—in short, all the hustle and bustle of a street. We sat with our mouths open, without speaking, filled with amazement. (George Méliès, quoted in Toulet, 1995, pp.14-15)

The search for more intense projection experiences has gained impetus over time. Today, viewers immerse themselves in movies on giant screens at home or cinema, and in computer games with VR glasses on. The use of multifunctional screens and applications raises the issue of passage in the design of smooth transitions between all the different platforms available. More generally speaking, the desire for passage experiences is something that lies deep within us. Our bodies deserve to be called bodies because they feel and move (Massumi, 2002, p. 1). We are fluent creatures, in need of continuous change, ongoing evolvement, and progression. Thus, the demand for concepts and designs for passage experiences is a fundamental one. This chapter consists of two subsections: “The Passage Moment in Architecture and Literature: The Arcade”; and “Le Passage: An Archaeology of Scalar Transitions.” First, I will explore the passage moment as furthered in both architecture and literature, focussing on the concept of the arcade, and demonstrating how Walter Benjamin’s work has influenced my own design practices. Second, I will present an archaeology of scalar transitions—from the 1968 film *Powers of Ten* to the latest Google Earth applications and the Worldviews Network—illustrating how such transitions may influence our passage experiences and ultimately, the knowledge and perception we gain from

them. Concluding, I will present my concept of “Le Passage” as a design and knowledge concept that is capable of fulfilling our desire for embodied passage experiences without losing our sense of connection—both to ourselves and to the planet.

2.2. The Passage Moment in Architecture and Literature: The Arcade

Turning now to architecture, the author and architect Simon Unwin (2007) elaborates upon the moment of passage in his book *Doorway* as an in-between experience in architectural space. He states that this “space in-between” (p. 389) as he calls it, can be a long experience, as in the departure hall of an airport before embarking upon a flight or a train ride—a transition state between different cities (Unwin, 2007, p. 163).² Alternatively, it can occur inside the sharp, two-second step between a glass door, whilst passing from one room to another (Unwin, 2007). The in-between moment is crucial, as it can liberate. It can have that wonderful effect of a total change of perspective—a reset of the mind. To further our investigation into the “in-between” moment as a long-lasting experience, we now turn to arcades, which provide both the time and space for intensive passage experiences.

The term “passage” (in French *le passage*, and in German *die Passage*) has several meanings in French and German. In German these are, for instance,

² A train ride was already discovered to be a specific moment of transition at the 1900 Paris Exposition Universelle, as the Trans-Siberian Railway Panorama illustrates (see subsection 1.1.4 of Chapter 1 for further details).

passieren and *durchgehen*, meaning to pass through or walk-through (Duden onlin).³ A passage can mean a narrow spot, which only allows a walk-through at that position, or a short street with shops for pedestrians that connects two streets together. Further meanings can be a street, or a hallway with a covered glass ceiling, such as the arcades we know today. Wider meanings encompass ship crossings or long ocean voyages; a passage of text in a book; or, in the context of horse-riding, a specific type of trot, in which the horse keeps the diagonal pair of legs longer in the air in a sort of abeyance. In a musical context, passage stands for fast ascending and descending sounds in a tone row, whilst in astronomy, the German word *Passageinstrument*—a “passage-instrument”—stands for a measuring tool that is used to measure the transit times of stars in the meridian. All of these interpretations of the term “passage” have one element in common, which is the moment of crossing and a liminal state—something that is restricted to a specific time or space (Schmeer, 2008, p. 1). Both aspects relate to the building classification of arcades, which in German are also called passages—passages for passers-by. The arcade is spatially restricted, as it is an autonomous building in which visitors stay for a limited period of time. It stands alone—mostly on its own piece of ground (Geist, 1979, p. 12). Johan Friedrich Geist (1979) examines the arcade in his dissertation (and subsequent book) as a specific architectural construction and a typical building of the 19th century. Conversely, Walter Benjamin (1991) is more interested in the arcade’s philosophical in-between state, as it emerged in the early 19th century—a period during which some arcades

³ Retrieved from : <https://www.duden.de/rechtschreibung/passieren>

vanished at the same time, simultaneously representing both the success and the downfall of *le passage*. Kristin Schmeer (2008) also finds this phenomenon intriguing. In her well-researched paper on the history of the buildings known as arcades or passages, Schmeer reveals important factors that may have caused some arcades in Paris to vanish. The first arcades, however, must have initially benefitted from the poor condition of the streets in the 18th century, making walkers feel safe inside the arcades (Schmeer, 2008). For this reason, passages such as the Passage du Saumon (Figure 2.3) could flourish in all their glory.



Figure 2.3. Passage du Saumon, engraving by I. Nash, 1831. In all its glory, built in 1780 as an open-air passage, and at this time considered to be one of the most frequented galleries in Paris. It was demolished in 1899.⁴

⁴ Retrieved August 19, 2018, from https://commons.wikimedia.org/wiki/File:Passage_du_Saumon,_1831.jpg.

One should not forget that at that time, the streets were heavily used by coaches, which presented a real threat for pedestrians. In addition, there was extremely poor drainage—wastewater ran down the middle of the street—a fact illustrated in Figure 2.4 below.



Figure 2.4. Street conditions in Paris. Street Conditions, drawing by the French painter Honoré Daumier (n.d.).⁵

Only when Baron Hausmann equipped the city of Paris with an underground sewer system was the arcade's attraction diminished (Geist, 1979, p. 92). Ironically, Schmeer (2008) notes that industrialisation—which was responsible for the immense prosperity and splendour of the passages through the combination of iron and glass, allowing impressive shop windows and curved glass ceilings—was to be at the same time, at least in part, responsible for their atrophy. These new

⁵ Retrieved August 19, 2018, from http://www.presidentsmedals.com/showcase/2013/l/1386_15112503681.jpg

materials, such as iron girders and large glass surfaces, enabled the construction of innovative buildings—railway stations and large department stores—which slowly became the new magnets for the pedestrians of the city of Paris [Schmeer, 2008].

2.2.1. The Taxonomy and Function of Arcades

A significant characteristic of the Parisian arcade was its function in guiding pedestrian traffic and as a means of escape from the vehicular traffic of the city. Arcades were built between streets, and thus they were frequently used to allow short cuts or alternative paths through the city. Another aspect was the ambivalence between exterior and interior space [Schmeer, 2008]. The aesthetic of the various arcades in Paris varied significantly; from dark, tunnel-like thoroughfares to bright, glass filled transparent passages that allowed views both to the outside, and from the outside to the inside, as seen in the photograph of the Passage des Princes by Jean Claude Dresch below (Figure 2.5).



Figure 2.5. Passage des Princes, photograph by Jean Claude Dresch, 2015. © Jean Claude Dresch.⁶

The glass enabled pedestrians to experience walking both through the arcade *and* through the city, which could be observed through the glass ceiling.

The internal design of an arcade is realised through a blend of interior and exterior architecture. Both Schmeer (2008) and Geist (1979) suggest that the internal architecture of the arcade consists of the following elements: 1. multiple shop fronts; 2. glass ceilings, as an independent element, having developed from wooden roofs to glass vaulted ceilings; 3. two entrances; 4. advertisements in the

⁶ Retrieved August 19, 2018, from <https://www.trekearth.com/gallery/Europe/France/North/Ile-de-France/Paris/photo1493048.htm>.

form of vitrines, posters, sign boards, goods and their associated branding. Considering the commercial aspect, the arcade is seen as an organisational form of the retail business (Geist, 1979, p. 12). Safe from the weather under the glass ceiling, the creators of arcades could concentrate on developing a microcosm of trade and entertainment (Schmeer, 2008, p. 2).

It is fascinating how simply the construction of a long passage could enable the rise of such microcosms. Through its specific arrangement it provided space for elements that would otherwise be lost in the outside city. It may thus be advantageous to think of adapting this concept into a passage experience inside the 360° format in order to explain different, detailed aspects of a complex scientific model before the audience gets ultimately immersed inside the complete model or natural phenomenon.

2.2.2. Panorama Arcade

Turning now to a specific Parisian arcade, namely the Panorama Arcade (in French *Passage des Panoramas*). This arcade was built in 1799 between two panoramas, which gave the arcade its name. The construction of the *Passage des Panoramas* was inspired by the idea to build a connecting passage between the two rotunda buildings on the Boulevard Montmartre to make the panoramas more attractive, as seen below in Figure 2.6 (Schmeer, 2008, p. 19).

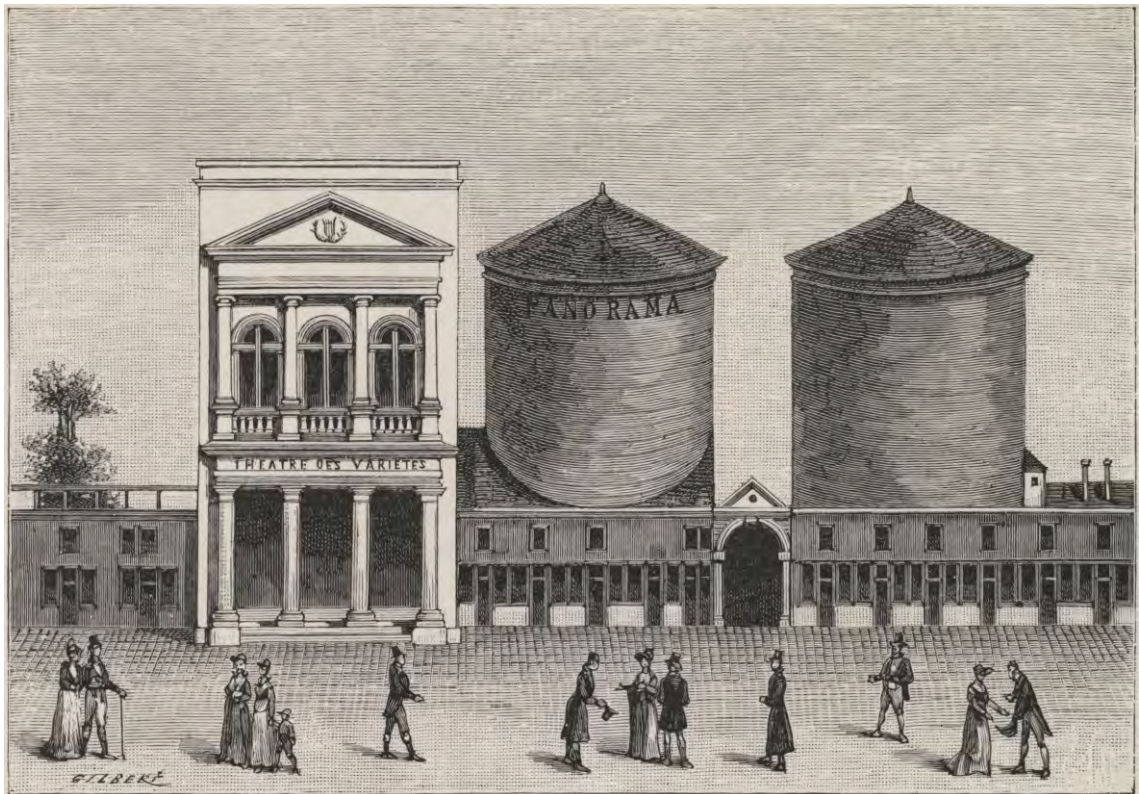


Figure 2.6. Illustration of Passage des Panoramas. Paris sur le boulevard Montmartre, engraving by Gilbert, 1802. Reprinted in "Essai sur l'histoire des panoramas et des dioramas" (pp. 14–15), by Germain Bapst, 1891, Paris: Imprimerie nationale..⁷

The success of the panoramas led James Thayer to build a third panorama (Geist, 1979, p. 264). It is interesting how, in 18th-century Paris, the 360° worlds of the panoramas were connected to the passage between. Further passages were built, such the Passage Jouffrey in 1845 and the Passage Verdeau in 1847, and together they formed a linear, independent system, about 400 m in length, which was only accessible to pedestrians (Geist, 1979). Below, in Figure 2.7, is a graphic showing the entrances through the various galleries and passages, as well as how they interconnect with each other.

⁷ Retrieved August 19, 2018, from <https://gallica.bnf.fr/ark:/12148/bpt6k116928k/f18.image.textelImage>.

Today one can find the *Passage des Panoramas* on Google Earth—a survivor located between Rue Saint-Marc 10 and the Boulevard Montmartre (Figure 2.8).

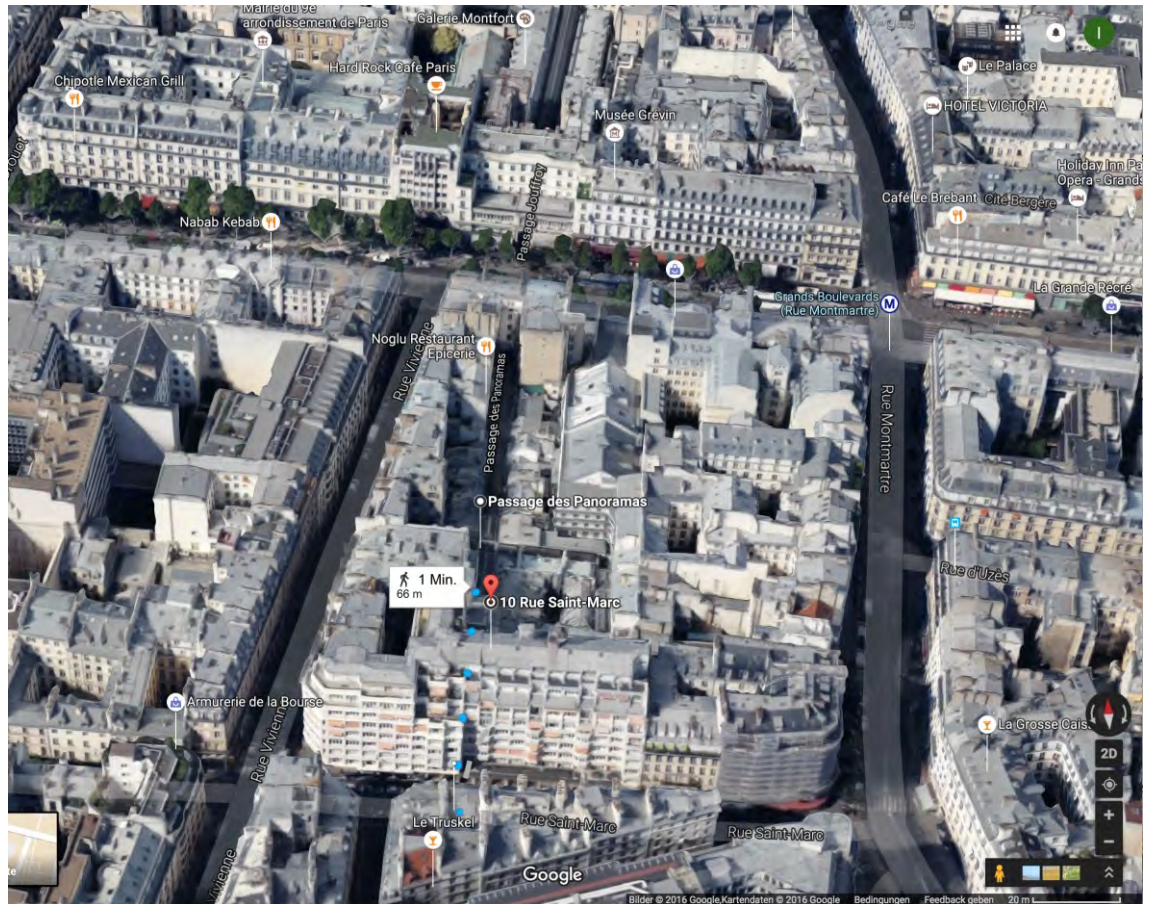


Figure 2.8. Passage des Panoramas on Google Earth © Google (November 19, 2016).

There remain 21 arcades in the city of Paris today, of which 19 are open to the public (Paris's top 10 hidden shopping passages, 2012). They are all located on the right bank of the Seine and have either a north-south or east-west orientation. Schmeer (2008) suggests that through the idea of individualisation—in contrast to the mass products and stereotypes of the new department stores and shopping malls—some of the old arcades could be revived. Small handicraft businesses in fashion, jewellery, and art could find suitable shop areas and settle down in the arcades. The *Passage des Panorama* survived primarily by appealing to a select and very specific circle of customers. Today, the arcades are frequented by

tourists, advertised as “the secret passages of Paris” or “a labyrinth of hidden passages across Paris” (The Guardian, Brunton, 2012, para. 1).⁹

2.2.4. Walter Benjamin’s Flâneur and the Passage as a Symbol of 19th-Century Paris



Figure 2.9. Examples of arcades and passages as Benjamin might have seen them in Paris between the 18th and 19th centuries. From left to right: Passage Choiseul in Paris, 1910 photograph by LL, Roger-Viollet, The Image Works. In *The Arcades: Contemporary Art and Walter Benjamin*, 2017¹⁰; Unnamed photograph by n.n., [n.d.], archived at the Walter Benjamin Archive, Berlin.¹¹

For Walter Benjamin, the Parisian arcades play a much deeper role. Benjamin is captivated by all sorts of “passage moments” that emerge inside the Parisian arcades, as well as elsewhere in the everyday city life of Paris at that time.

In fact, he may have seen the city of Paris as an “action immense,” in the same

⁹ “At the end of the 18th century, town planners in Paris created a labyrinth of hidden passages across Paris. Over the years many fell into disrepair or were demolished, but if you know where to look you can still push back a doorway and walk into” (*The Guardian*, 2012).

¹⁰ Retrieved October 20th 2017: https://www.timeout.com/newyork/art/the-arcades-contemporary-art-and-walter-benjamin#tab_panel_3

¹¹ An image taken from Walter Benjamin’s archive, as part of his research into the Parisian arcades—the cluttered arcades of the Bourgeoisie, reflecting the individuals and culture they are part of. Retrieved May 13, 2017: <https://thedisplacedcity.wordpress.com/insights-on-the-city/>

sense as theorised by Valéry (Stierle, 1993, p. 12). This term refers to an activity beyond measure, consisting of endless individual actions, “*comme une nébuleuse d’événements*”—“a milky way of events” (Stierle, 1993, p. 13, translation mine). It required an unusual degree of intellectual ability and conscious effort to recognise the city’s structure as such (Henopp, 2008, p. 1). Benjamin tried to develop a narrative by which to “read” the city of Paris. He was the first to propose a way to enable the philosophical readability of the 19th-century capital (Henopp, 2008).

Benjamin’s work *Das Passagen-Werk* is often referred to as *The Arcades Project* (Benjamin, 1991). The work is held in high regard, not least as it tries to develop a new style of reading—one which is very fragmented in nature. This risky reading technique makes a text appear as a locus of fragments, of broken bits; a “kaleidoscope of the senses” (Henopp, 2008, p. 3; Stierle, 1993, p. 17). In essence, it allows the reader to continually access new aspects and details. Henopp (2008) explains how the reading of a given text matures through time and—being a phenomenologist of modernity—Benjamin tries to apply this technique to reading the city of Paris.

The text is specifically arranged using both French and German, and through the process of reading the passage function develops its effect. The reading process connects all the separate notes and paragraphs in both German and French with each other, which can vary in order, due to the preferred reading direction of the reader. The passages have tremendous significance in Benjamin’s work, as they are symbolic of the 19th century. They can either be perceived as a cross-over

between text and city, or as essential components that make the city readable, as passages are the loci of the volatile (in German: *des Flüchtigen*). Whilst Parisians used the passages in the city to escape from their daily routine, Benjamin identifies the transitional experience of a passage as healing: “How much healing a rite of passage, a transitional experience might be, which becomes alive inside the classical covered walks, in which the sufferers convert and walk towards their healing” (Benjamin, 1982, pp. 515–516, translation mine).¹² Benjamin believed that the process of passing and change can have a revealing and healing component. Fascinated by the manifold effects of passage moments, he searched and described various threshold moments in the metropolis of 19th-century Paris. For example, the portals and gates of the French shopping passages are described as thresholds: “These gates—the entryways of passages—are thresholds” (Benjamin, 1991, p. 42). Benjamin further distinguishes between boundary and threshold: “Whereas a boundary is a line that separates, a threshold is a ‘zone of transition.’ Thresholds are interesting since they allow passages over them, transitions between spheres or states: while boundaries tend to halt movements, thresholds invite innovative change” (Benjamin as cited in Fornäs, 2002, p. 3). As another threshold zone, the doorstep is analysed. The doorbell is described as a despotic affright, presiding over the apartment and drawing its power from the magic of the doorstep-threshold: “Something prepares screamingly for passing the threshold” (Benjamin, 1991, p. 141, translation mine).¹³

¹² German original: “Wie sehr auch Heilung ein rite de passage, ein Übergangserlebnis ist, das wird in jenen klassischen Wandelhallen lebendig, in denen die Leidenden gleichsam ihrer Gesundheit entgegenwandeln. Auch diese Hallen sind Passage.”

¹³ German original: “Gellend schickt etwas sich an, die Schwelle zu überschreiten.”

The architect and professor Jörg H. Gleiter (2008) summarises how Benjamin's work resulted in a specific technique, namely that of the benjaminische Flâneur ("Benjamin's Flâneur"). The Flâneur does not use the city for representation or as a background for self-display. Rather, the city serves more as an epistemological instrument. This phenomenon is specifically related to the disorientating experiences of urban life. As an example, he refers to Friedrich Wilhelm Nietzsche and his experience of the Italian town of Turin, which appears squared and rigid, having endless covered halls, arcades and passages (Gleiter, 2008, p. 106). Thinking this concept further, these endless passages help to both disorientate and awaken ideas of a new assembly of the city. Henopp (2008) describes the Flâneur as a huntsman, hunting the city for signs. Through his personal experiences, the Flâneur transforms the city into a kaleidoscope of the senses, enabling himself to recognise and read new city signs (Henopp, 2008, p. 12). I wonder if the 360° visualization of a passage could have helped to construct for Benjamin an additional more whole and complete passage imagination as well. The whole 360° photograph taken with a fish eye lens of the Milan passage can be seen in Figure 2.10 for comparison.

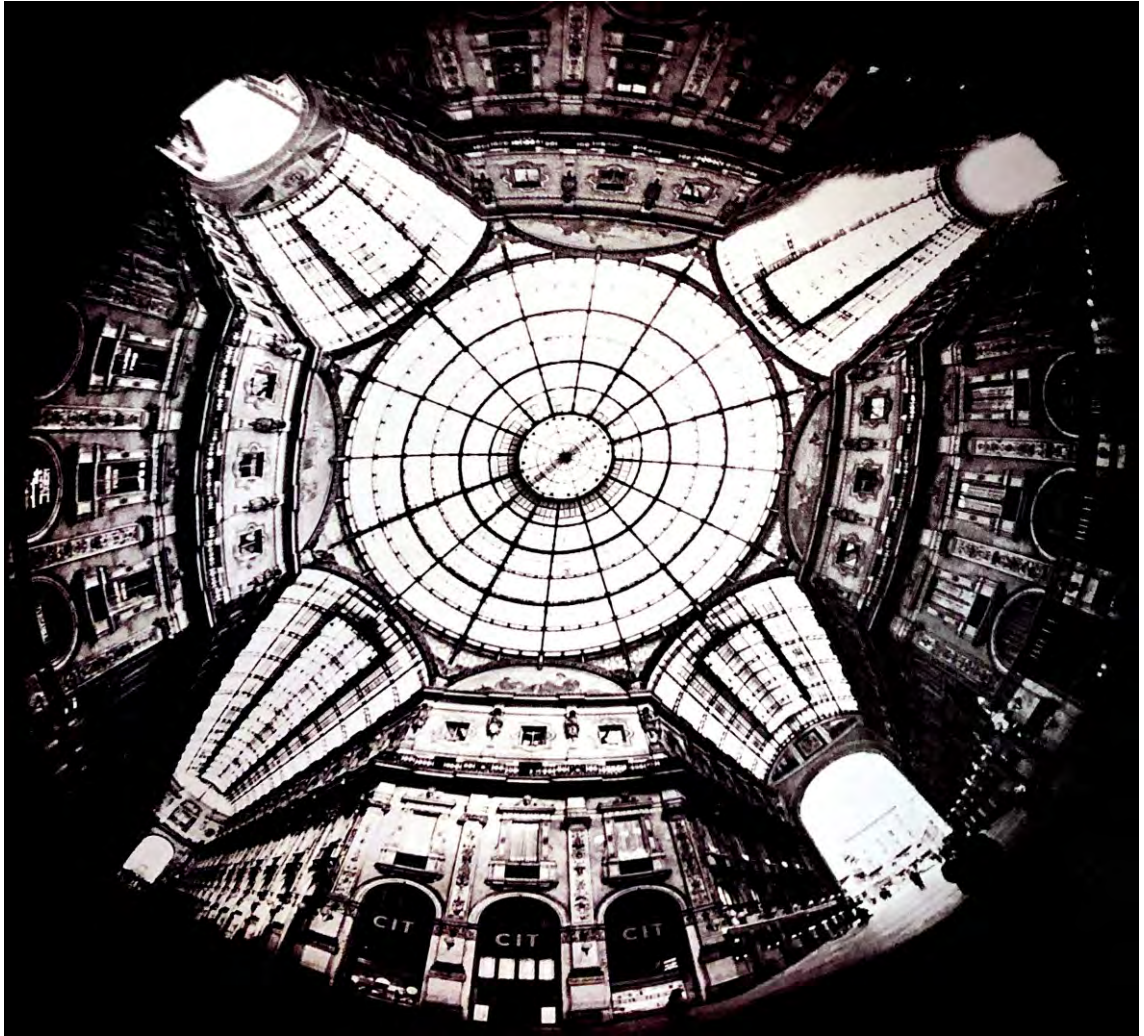


Figure 2.10. Galleria Vittorio Emanuele II with passages in Milan, photograph provided by Geist (1979), figure 149 (no page)

2.2.5. Kaleidoscopic Passage

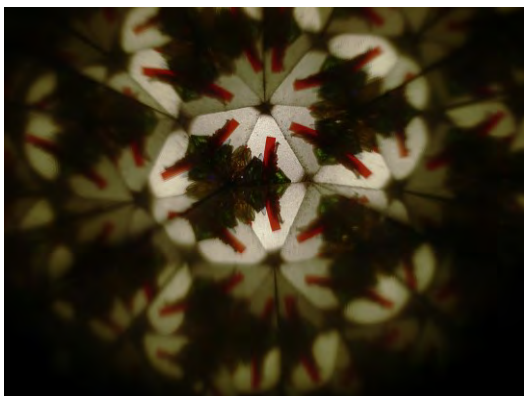


Figure 2.11. Kaleidoscopic Perspective. A kaleidoscopic pattern made using a toy kaleidoscope tube. Photo, by n.n., 21 July 2005. English Wikipedia.

In my paper “The Immersive Dome Environment (IDE): Old Concept in a New Light or a New Hybrid Medium to Enhance Human Cognitive Faculty?” (Buczek, 2011)¹⁴—which was prepared for the Transcultural Tendencies | Transmedial Transactions conference in Shanghai, August 26–27, 2011—I compared the IDE with Michel Foucault’s concept of heterotopia (Foucault, 1984). Consisting of the Greek words “hetero,” meaning “other,” and “topos,” meaning “place,” Foucault’s concept refers to places that are simultaneously part of, yet radically different from, the established order of things—such as ships, gardens, and brothels (Foucault, 1984). Similar to heterotopia, the IDE is a place that is both “other” and unique. It is a medium that has traversed time and is still in existence. Being both “other” and of existence, it reveals what is generally missed by society in the urban space, or equally by individuals. The act of continuous storytelling about, for example, the Big Bang and how our universe came into existence, can be quite comforting in the context of the fast and rapidly changing media society and the development towards *fractal spaces and fractal minds* (Mersch, 2011), providing a sense of stability.

The creation of an illusion or a space that is “other” has its roots in the history of the planetarium which, from its very first incarnation, has demonstrated the constructive interweaving of advanced technology, spatial illustration, and enhanced cognitive faculty. Projection instrumentation, including dome-based video projection, has enhanced and expanded upon the abilities of the

¹⁴ The paper is included in the Appendix of this dissertation. A publication of the conference did not take place.

planetarium, creating a heterotopia of illusion—one that continues to tell the story of the universe today. Most importantly, the planetarium continues to accumulate knowledge—now in digital formats—via images or data files that span centuries, documenting the history of astronomy and knowledge about our planet. The storytelling that takes place within the IDE reuses fragments of knowledge in ever-changing arrangements. Its inherent spherical distortions favour kaleidoscopic images, not least as this is the only visual format (apart from a drawn six-point perspective; see also subsection 6.1.5.1 of this chapter) that appears correctly on the curved surface of the dome without going through additional (corrective) distortion processes.

In some ways, the IDE could even be regarded as a kaleidoscope in itself; in a way similar to Benjamin's (1979) *Flâneur of the city of Paris* (see Chapter 2), the viewer becomes a *Flâneur* of a kaleidoscopic narrative journey through the universe, which is enriched by fragments of knowledge, such as stars, pulsars, galaxies, planets, data extracted from light spectrums (both visible and invisible), time and spatial slices of specific natural phenomena, as well as slices of historic discoveries—as a container of accumulated knowledge. The viewer is guided through this container, resulting in a kaleidoscopic journey or passage. In the 360° space, it is the viewer's perspective alone that provides the thread that ties this narrative playground together.

2.2.6. A Case Study: Passage des Panoramas and My 360° Film Project “VIP”

The *Flâneur* could walk through the *Passage des Panoramas* and, when ready, enter the 360° panoramic world. Once satisfied, the panorama inside the rotunda

building could be left and the visitor could walk again through the passage to reach the next panorama and immerse him- or herself inside its 360° display. Thinking this concept further reveals an image of a structure of parallel passages that coexists with the outside city and seems alive through the performative walks of the Parisian pedestrians using the passages.



Figure 2.12. My own sketches: 01. Passage; 02. Rotundas and the Passage des Panorama; 03. Rotundas and passages thought further; 04. Spheres and passages from my 360° film project "VIP". Buczek, 2004.

The image map presented in Figure 2.12 was adopted intuitively into my very first 360° film project entitled "VIP," made in 2004 and produced together with 3D artist Bob Weber. The idea was to create a passage ride with tunnels and spherical spaces through the living memory of a VIP (a celebrity). Pop song lyrics, provided by the band Fury in the Slaughterhouse, were used as a basic inspiration for the visual concept of the 360° film. The spherical, all-around spaces were living memory worlds, which were intended to unfold their full intensity through the narrow passages in-between them. The viewer entered the ride through the first passage tunnel, first flying through it to prepare, and then being absorbed into the first full spherical world, floating across it until entering the next tunnel passage to the next world-sphere, and so on. In summary, there were three worlds. Upon exiting the last sphere, the flight changed into a slow-motion drifting. Looking back, the passengers had time to realise that they had just been flying through

the loud, conserved memories of a deceased celebrity inside an urn, drifting endlessly through the universe.

The passage flights through the tunnels were designed slightly differently: some of them were dark and narrow, whilst others were half transparent, revealing the outside universe and stars, the sphere-tunnel structure itself, and the outside structure of the urn, as can be seen in Figure 2.13 below.

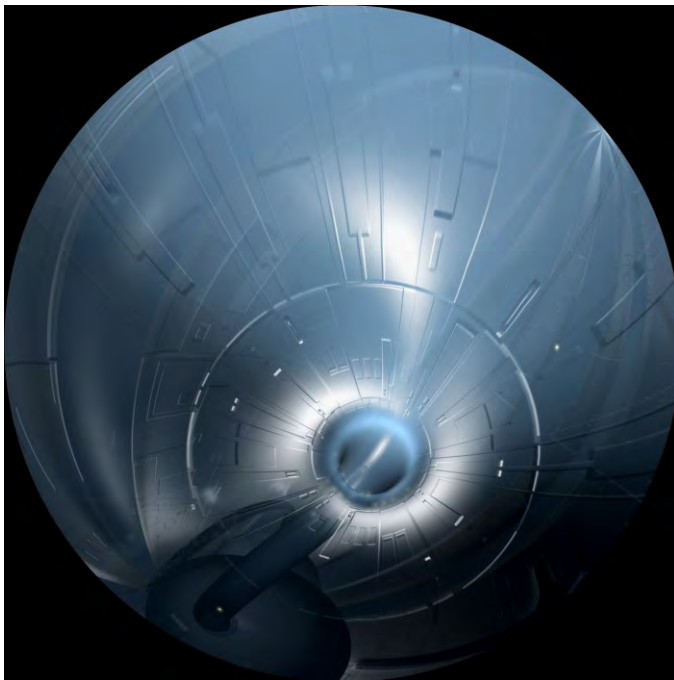


Figure 2.13. Work sample, 360° film “VIP” being shown at the opening event of the Kiel and Hamburg Planetarium in 2004, Bob Weber and Isabella Buczek (2004).

2.3. Le Passage: An Archaeology of Scalar Transitions

A very distinct passage moment is when a scalar transition occurs in a geographical visualisation. Irrespective of the medium, whether it is a personal mobile device, a 360° projection dome, or a 360° video inside a browser on a flat screen, these experiences all include a moment of navigation and transition.

2.3.1. Scalar Transition in Powers of Ten

The first concepts for scalar transition are to be found in the book *Powers of Ten: About the Relative Size of Things in the Universe* (1994), by Philip and Phyllis Morrison and the Office of Charles and Ray Eames. The initial inspiration for this book came from the Dutch educator Kees Boeke and his essay “Cosmic view: The Universe in 40 Jumps” (1957), in which he suggested combining the ideas of orientation by scale into film. As an architect, Charles Eames had a different perspective on the world, and he loved the art of estimation (Eames, 1994, prologue). If used correctly, it can be a knowledge instrument that can bring very small or very large quantities within our grasp and, most importantly, in relation to each other. In order to achieve this, the designer needs to find commonalities between them; weave a concept in the sense of an intelligent cobweb between all the chosen magnitude quantities and place them inside this context so that it would be possible to experience them inside an illuminating process of discovery for each human being. In the best case scenario, this experience would be connected to the spectator’s spatial image of the world.

For Charles Eames and fellow designer Eero Saarinen, it was crucial to always look for the next larger thing—and the next smaller (Eames, 1994). The concept of scale and the relationship of each scale to the other is not only of importance to architects, but represents a knowledge concept in its own right. The film *Powers of Ten* (Eames, 1977). applied this concept, with a constant time unit for each power of ten, in which a photographic move was realised. That way the effect of adding subsequent zeroes could be shown—and put in relation to each other. Moreover, a new and specific context was created scale by scale. The programme

book *Powers of Ten* (Morrison, Morrison, & the Office of Charles and Ray Eames, 1994) can be understood as a guidebook for this journey. Inside the book, the journey is presented as a series of jumps with additional information. At each stop in the book, and in the film, the Eameses and Morrisons tried to realise a smooth flow with the limited technology available at that time. It can be understood as a very successful concept with which to approach and engage anyone and introduce them to the science of the very small and the very big. The observer is transported from the relative, known, and daily experienceable size within their grasp and then slowly led to smaller—or larger—scales. In doing so it offers a fruitful guided look at the world that goes beyond the extracts, images, and models that we are used to seeing in scientific magazines or documentaries that introduce us to scientists and their lifeworks. These forms can only show a specific extract of their specific discipline in their laboratory—an isolated model or separated world. The worlds they research and are used to seeing through their specific instruments probably develop a distinctive “tunnel look.” However, the scalar transition concept not only shows new insights into the world at different degrees of scale, but also offers a contextual framework and the possibility of a continuous passage or transition—a full embodiment through vision, time, and passage.

Of course, the scalar transition is a concept that could also be changed or utilised in other areas. Firstly, the multiplication factors could be changed to smaller or larger scale steps, whilst secondly, the environment could be changed. For example, such a context of transition could be used to dive into the ocean’s depths and experience this environment at different scales, or it could be used to enable a journey into the past and experience the evolution of life on our planet. Of course,

there are many attempts to illustrate the evolution of life in documentaries and sometimes in planetarium shows, however, they all miss such a continuous framework in time or scale. Pivotal moments, such as the emergence of the first forms of life, dinosaurs, and the first human beings, are somehow accumulated in a way that makes them visually the most appealing, in the process losing any relation to each other, thus becoming decontextualised.

Yet, if done correctly, such visual models can provide extremely powerful tools towards gaining an overall understanding. As Ray Eames noted, “it is probably true—truer than the specialists might be willing to admit—that the linked conceptual structures of science are not more central to an overall understanding than the visual models we can prepare” (as cited in Morrison, Morrison & Charles and Ray Eames, 1994, p. 1). What this means is that, not only can such a visual model contribute to an overall understanding, it can even be more important and central to the public than linked conceptual structures developed in science labs (an argument that will be further explored in Chapters 3 and 4). I would now like to explore further the effect of visual models built by zoom-transitions, building upon the ideas explored in this section.

2.3.2. The “Zoom Passage”

The “zoom passage” had its various forms from the unchained camera techniqueⁱ that emerged in the early cinema of the 1920s, through to the expanding concept of a scaling zoom towards a cosmic view by (as previously mentioned) the Dutch educator Kees Boeke (1957) in his essay “Cosmic View,” as well as in documentary films such as *Cosmic Zoom*

(Szasz, 1968), Powers of Ten (Eames & Eames, 1977), and Cosmic Voyage (Silleck, 1996). In a contemporary context, various zoom effects are being used daily in diverse applications, serving as “passages.” Yet whilst commonly using passage-zooms, we have somehow lost an awareness of their meaning:

You know, the time when you leave one country—you take a plane, you go to the train station, to wherever. And then you go somewhere else. But before you arrive, that space in-between—that’s the space where it is most intense. It’s the space where you’re open, where you’re sensitive, vulnerable—and anything can happen. (Marina Abramovic cited in Unwin, 2007, p. 124)

As mentioned in subsection 1.2. of this chapter, Unwin establishes here the experience of a threshold in his words: “A threshold offers the opportunity of a seam in one’s experience of the world” (p. 232), a transition, and the in-between space created whilst passing through architectural spaces. I take the concept further, looking at technology-driven zooms and passages leading from one location to another or, in movies, from one scene to another, in immersive projections, or even in geographical applications on contemporary end-user mobile devices. These passage experiences can differ significantly in their intensity and some of them can have a very strong impact on the user’s self-constitution: “a transition, a ‘passage’ from one realm to another, from the immediate physical reality of tangible objects and direct sensory data to somewhere else” (Huhtamo, 1995, p. 159).

2.3.3. Constructing “New” World Models in the Mind

Through my work at different planetariums, I learned that audiences tend to leave the cupola with quite different impressions. There is obviously an important difference between the simulation of the skies in a fulldome theatre and the real sky that can be seen in an observatory. This raises a fundamental problem: Some of the audiences coming into the fulldome theatres do believe that they are about to see the real night sky, and therefore a real-world environment. In some ways their personal concept of the earth and the night sky blurs with the Digital Universe Atlas (DUA) model that we show them in the dome, creating something new—hopefully, in the best-case scenario—a new, wider model concept in reference to their own location on earth. Yet, this raises the question of how coexistent and complete this new model can become in their mind.

Fulldome designers, producers, and creators are responsible for exactly how this establishing of a “new” world model occurs in the minds of their audiences. However, this mind concept is extremely difficult to grasp, since it exists in a continuous state of flux due to the changing media landscape, and the usage of different media devices, all of which blend together on a daily basis. For example, the frequent usage of navigational tools when driving a car, looking up a destination, or planning a holiday using Google Earth or Street View, shapes and strengthens our imagination of distant places, not least because they are digitally omnipresent and always available as long as there is a net connection—a proof by visual evidence.

2.3.4. Guiding Technique of a Zoom

Most importantly, all of these tools employ an inherent guiding technique—that of a “zoom”—leading the user towards the surface of the location they choose. This zoom effect enables the passing experience needed in order to enter further details, landscapes, regions, cities, streets, houses, people, objects, or—as Garrett Stewart (2007) summarises it—“as when plummeting from satellite range to a facial close-up, or lifting back out again’ (p. 283). This scalable transition is a technology-driven effect rather than a real passing through either space or time. In these moments, there is no time and space constraint—we are simply “swooshed” to the other point in space—whichever point we chose to navigate to.

Further to this, we cannot only zoom into these chosen places, but we can also explore them virtually. We perform—to use the term deployed by Nanna Verhoeff (2012)—and memorise them in a specific manner. Verhoeff claims that the use of technologies such as GPS, in which our movement produces the map, allows us not only to navigate space, but also to construct it. This creative cartography is a subjective, flexible, and open-ended practice of personalised space mapping (Verhoeff, 2012). The software applications we use, with their inherent zoom functions, search algorithms, and selected scale structures, have a tremendous effect on the production of knowledge in general as well as on the user, both inside the process of performing with the application and afterwards in the memory that results from its use.

2.3.5. Geographical Scale and Models

Significant research has been conducted in the field of geographical scale. Works such as *Reassembling the Social: An Introduction to Actor-Network-Theory* by Bruno Latour (2005); *Scale* (2011) by Andrew Herod; and, in the field of ecocriticism, *Sense of Place and Sense of Planet: The Environmental Imagination of the Global* (2008) by Ursula Heise will be used in what follows as a means by which to reflect on the issue of scale.

Herod (2009) recognises that there is an important relationship between geographical scale and knowledge production—I would emphasise specifically when scale structures are being created by software and performed daily by billions of people. He states: “the idea that the world is scaled (or not) recursively shapes how we comprehend its nature. In other words, ideas about scale structure the knowledge we create about the scaled nature of world” (Herod, 2009, p. 255). Herod introduces three models of scale: First, the “hierarchical ladder,” which is the one most commonly used, for instance by Google Earth or in *Powers of Ten* (Herod, 2009, p. 226). Each ladder “step” represents a scale size in a vertical arrangement. “The global is ‘above’ the national, the national ‘above’ the regional, and the regional ‘above’ the local” (Herod, 2009, p. 226). Secondly, he introduces “a series of ever-larger concentric circles,” which are orientated horizontally and contain one circle inside the other, each circle representing a change in scale (Herod, 2009, p. 226). The circles vary from each other in reach and in some sense can be seen as more democratic than the ladder model. The third, “nested hierarchy” (Herod, 2009, p. 227), is the Russian doll model, called Matryoshka. The Matryoshka dolls are nested inside of each other. Each scale size

is represented by a doll, which contains and is contained by another doll. This model contains both of the above; there is a horizontal arrangement of the concentric circles in the middle of the dolls, when the upper half of all dolls is removed. There is also the vertical component of the ladder model, when the dolls are lined up alongside each other (Herod, 2009).

For his actor-network model, Bruno Latour replaces the traditional parameters for interconnectedness as mentioned above, using instead “close and far, up and down, local and global, inside and outside” through mutual “associations and connections” (Latour, 1996, p. 372). “In the context of Actor–Network Theory ANT, ‘scalar travel’ does not simply mean zooming in or out from one scalar level to the next, but rather tracing the connections of actors in spite of scalar preconceptions” (Latour, 2005, p. 186; see also Tong, 2014; McConville, 2014 on transcalar).

Heise (2008) proposes a shift from “a sense of place to a less territorial and more systemic sense of planet” (p. 56), and points instead to the spectrum of scalar levels that lie in-between. She is further concerned with the concept of scale in general, noting that “scale can vary enormously” (Heise, 2008, p. 45) and pointing to Lawrence Buell’s words, in which he argues that place can be “as small as a corner of your kitchen or as big as the planet” (Buell, 2005, p. 62). In search of more precise differentiation and new solutions, Heise (2008) looks into the different concepts of the imagined global environment through collage and fragmentation—as inside Google Earth—in the sense of a new collage narrative, which she compares with collage techniques from documentary, novels and

science fiction writers—techniques that writers such as David Brin and John Brunner use to allow jumps of spatial and temporal scale (Heise, 2008).

However, Latour (2005) problematises this, further suggesting that we tend to imagine scale in the order of “macro, meso, micro,” as a “well-ordered zoom” (p. 185). Therefore, Latour criticises the *Powers of Ten* concept as “marvellous,” but “misleading,” because it reinforces a vertical hierarchical ladder and appears to have an omnipresent perspective. For him, the film raises obvious questions, such as why precisely this cell’s DNA has been chosen, or this particular micro-organism, and not another one. (Latour, 2005) This raises the question of whether a generalisation of each element—as in, “at this scale the structures of cells normally look like this”—would be helpful. However, it is probable that—because of the immense diversity—this would not be possible.

Latour (2005) also critiques the various efforts to create a context. We live in an era of fragmentation—being in many places simultaneously on multiple devices. Mobility and availability are increased, meaning the ability to be anywhere at any given time now lies at our fingertips. The question here becomes: Is this not depriving our experiences of any context, the bigger picture, spatial relations, social relations; of any type of relation at all? Is it not quite natural that therefore we witness so many attempts to provide the spectator with a context, an order, anything to hold on to? A good example of this is the planetarium environment. Early planetariums were constrained by the technology available: there was a classical star projector, which had many constraints and therefore inbuilt relations. Planets could not be moved individually, because they were related to

each other through a certain mechanism; jumps in time caused a specific time to rotate the starry sky backwards. In a discussion we had at the Mediendom, Eduard Thomas (personal communication, 2016), Director of the Kiel Planetarium, said that in order to show the starry sky exactly at Jesus Christ's birth for a Christmas program, the star projector needed approximately one day and one night to rotate backwards to this timeframe. Today, the DUA enables jumps backwards in time in seconds, or—which is even more problematic—the time to travel to the next galaxy, for instance, can be adjusted by the user. Thus, the normal constraints of the human being no longer exist. In these systems, the earth and the universe are digitalised in a very fragmented and data-driven way. They seem to miss the common interconnecting factors, such as space and time constraint.

2.3.6. Google Earth and the World Zoom

Christ Tong—a postdoctoral researcher at Washington University, St. Louis—summarises this era of zooming with the term “The World Zoom.” In his 2014 article “Ecology without Scale: Unthinking the World Zoom,” Tong tries to elaborate upon concepts concerning interconnectedness beyond scalar notions. He approaches the interactive Google Earth model quite critically, in the sense that it represents information in a hierarchical order and therefore introduces an alternative model based on other relations than scale. The Google Earth zooming function will be further examined in the following paragraph, as it is well-known and used extensively to navigate the earth (Figure 2.14).

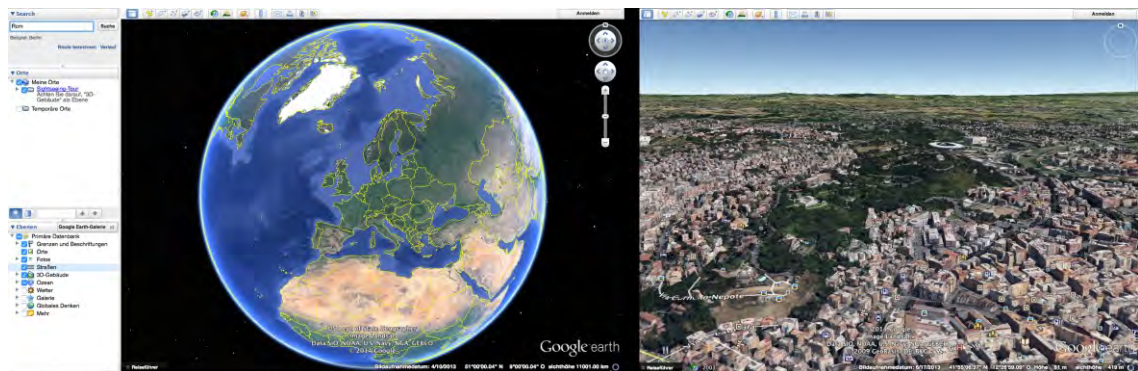


Figure 2.14. Spherical View and City View from Above, Google Earth, Google 2017.

Interestingly, Google Earth uses the concept of *Powers of Ten* quite cleverly, a link recognised by Tong (2014):

What Google Earth achieves in excess of *Powers of Ten* is to translate the film's frame-by-frame animation into an interactive application. As users, we manipulate and view—we animate—the geospatial images. In this sense, we are no longer passive viewers witnessing the world zoom, but active participants engaging in the practice. (p. 200)

This activation of the passive viewer is probably one of the aspects that makes the navigating experience playful, simultaneously encouraging a sense of autonomy. In Google Earth, the automatic zoom occurring once you have typed in your location—for example, “Rome”—is a rapid passing through different satellite images, which overlap on the virtual earth's surface in a straight angle, vertically and directly towards the chosen place. This approach is employed because for large parts of the earth's surface only 2D images are available from planar photography. However, from approximately 9–8 km above the surface buildings slowly start to gain rudimentary three-dimensional shapes, whilst at a level of 1 km a decent 3D orientation is possible.

Additionally, there is the option to see different photographs as fragments of a particular city from unknown users in a tour guide panel underneath. (Google Earth, Version 7.3) When the user chooses one of these photos, the user is zoomed (in a relatively clunky movement) to the photographed place or building, ending sharply in the planar view. The photos contain no information on the viewed angle, perspective, time, and distance when or from where the picture was taken. Only the author of the image is mentioned and a description appears, giving some details on the chosen object. The whole motion experience is fragmented and clunky, no connection passages are being made between the different locations, and no more spatial information (such as atmospheric levels, cloud formations, oxygen content, temperature, etc.) is provided. Satellite images are aligned to a virtual sphere floating inside a virtual empty space, without even the life-protecting atmosphere—a space built of many gaps and voids.

The problem is that these zooming experiences and movements are structuring and forming our perception of the real environment in a very specific manner through both technical interpretation and the individual picking of destinations by unknown users in a virtual coordinate system. In addition, these visualisations and maps—as stated by Mersch (2011, p. 55)—are instruments of domination: they do not represent, but rather construct the space in which we live. GPS mapping transforms the space into an available, mathematical territory—a territory that is available to everyone connected to the internet on any mobile device and at any given time.

One positive aspect is that in some way, this phenomenon democratises spatial knowledge, which was historically only available to the privileged, such as the members of scientific or political groups. It thus enables users to make discoveries of their own. Vincenzo de Michele, for example, discovered the Kamil-krater in Egypt in 2009 using Google Earth (Beyer, 2014). Google Earth are employing a similar philosophy to Wikipedia, allowing users to add their own 3D models using SketchUp (a 3D modelling software), as well as their own data models of earthquakes, 3D forests, etc. to the Earth Gallery.¹⁵

In summary, Google Earth's zooming technique allows the user to discover the planet at diverse scalar levels, yet at the same time transforming every unique and discrete being into "merely legible" data (Tong, 2014). Tong (2014) sums the point up well (with some irony), commenting on Google's vision: "Wouldn't it be nice for us to participate in the very information systems that treat us as data to be monitored?" (p. 201). Following the track of representation, it can be said that Google Earth, by zooming us through the different scalar levels, misses the contextual and spatial knowledge in-between. However, it does one thing very well: it delivers straight, and as fast as possible, all available visual information on your chosen location—even if that means plummeting through different satellite images on the way.

¹⁵ See the following link for more information: <https://help.sketchup.com/en/sketchup/viewing-your-model-google-earth>

2.3.7. The Remote Virtual Gaze and the Necessity of Embodied Experiences

When using navigational systems or Google Earth on a mobile device, the user is detached from the observed object and is thus essentially immobile. As Kim Jihoon (2014) an assistant professor in film studies states: “This immobility is counteracted by the viewers’ mobile and haptic gaze on the object” (p. 170). An operator using a device, for example to zoom down on a specific territory, develops a remote virtual gaze. This new understanding of seeing through the virtual gaze hopefully blends with the user’s own overview of the satellite landscape perspective. In order to process these inputs and thus to create a coherent model of a place, complex memory and abstraction skills are required.

Thus, a necessity arises to design full, embodied experiences for the usually remote viewer or “immobile mobile user” that offer visible context and thus connect the user with the surrounding environment by moving through it. It should be an environment that enables connections and relations between different spaces or objects in space; one that ensures both an overview and logical transitions or passages from one space to another, even if those spaces occupy different scales or ecosystems—from micro to macro levels. Most importantly, the experience should offer a space that would correct the misconceptions provided by commercial media or geo-visualisation tools. This environment can take the form of the Immersive Dome Environment (IDE) of a fulldome planetarium theatre. The question arises what factors should be taken into account whilst designing a model of a passage in this environment—which I call “Le Passage.” Take for

example a journey to a distant galaxy, covering thousands of light-years whilst simultaneously moving back in time. This is a very strong experience that is being used on a daily basis in most planetariums that have access to the scalable universe. However, this experience of passage has a myriad possible forms. The experience can completely distort the concept of the world and enable a new orientation. It can halt the passing of time, thus re-making the idea of the “void” into a new concept. It can neutralise, free the mind, and in doing so make space for a new model of our environment. It can both influence and change the user’s state of being. It can sensitise and raise awareness. For these reasons, this transition is a very important visualisation tool; “a knowledge instrument” in scientific communication—especially when used in the fulldome theatre.

The dome has an important inherent taxonomy (see Chapter 5), which is eminently suitable for the creation of passages and unique experiences. This taxonomy influences the way we tell stories in this specific environment. It naturally forces us to slow down camera movements and abandon any sudden cuts, sharp or chopped motions. We are constrained to design smooth transitions from one environment to another—a perfect flying vehicle for spatial passages.

At the Illusion Immersion Involvement Conference in Kiel in November 2014, a gaming professor from Flensburg University negatively claimed that the fulldome theatre is dogmatic by virtue of having an inherent slow motion constraint, a perspective that I found quite interesting. I think that we, as fulldome designers and content creators, are more than aware of the challenges that reside within this medium—for example to maintain audience orientation. Therefore, we do

produce transitions in various ways, often trying to avoid hard cuts. In my view, simply abandoning the medium is not the answer, as to do so would represent a major injustice to its potential—the “dogma” is very easily broken. Neglecting the medium would only serve to demonstrate a misunderstanding of its capabilities.

2.3.8. From Guided Tours to Navigational Narratives

Since slow movement through space seems so natural, one can therefore think of how to expand on it by creating the most intensive knowledge forming experiences—such as touring passages, or, as Ryan Whatt (personal communication, 2012) told me in a conversation at the International Planetarium Society Conference (IPS), by creating aesthetically sensible “guided tours” through the universe. At a conference in Baton Rouge, I was also able to discuss these aspects with other fulldome practitioners, namely Dan Neafus and Dr Ka Chun Yu (personal communication, 2012 and 2016). They gave some important insights into the creation of unique experiences under the cupola. For Dr Ka Chun Yu, for example, it was very clear how Uniview—a product by SCISS that includes the DUA—changes the way in which a narrative develops. He uses Uniview to create real-time voyages around the earth for planetarium audiences in Denver. Following the concept of Worldviews Network, Dr Ka Chun Yu uses the dome to illustrate planetary issues and problems. I used Uniview and KML-data files to illustrate the problem with water supply systems in Namibia (see Figure 2.15).

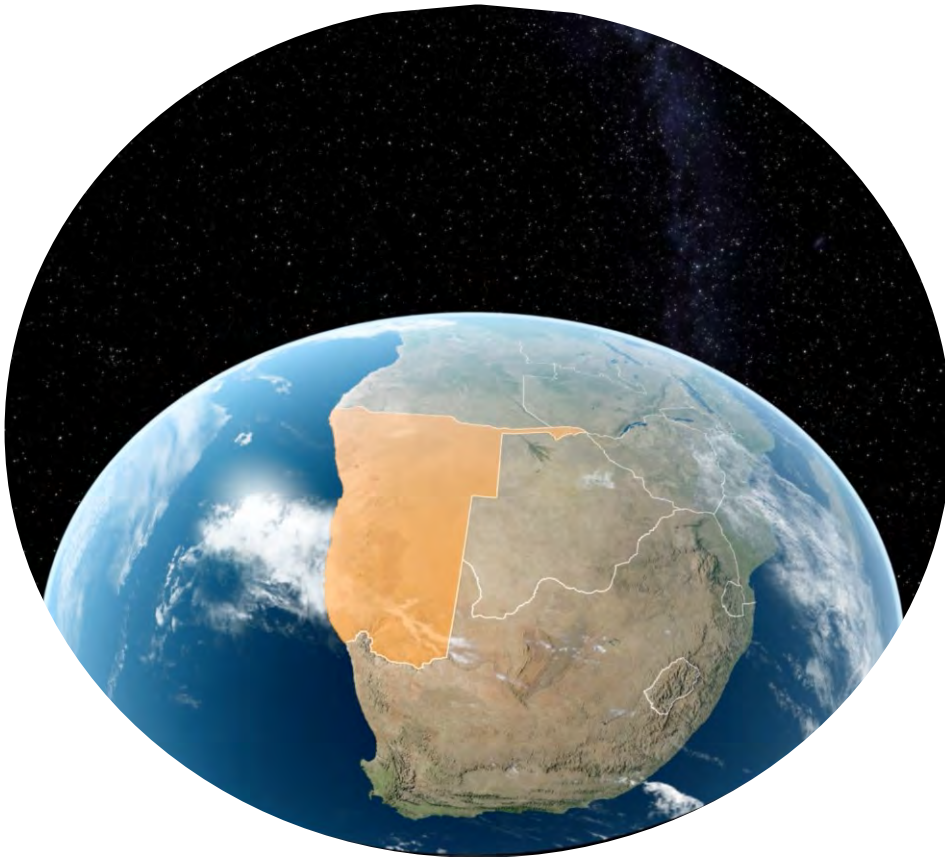


Figure 2.15. My own production, “Cuve Waters” (Beyer, 2013) for the German Federal Ministry of Education and Research on water management in Namibia.

The Worldviews Network, in combination with the DUA, invites us as designers to create seamless flights through different parts of the planet. Dr Ka Chun Yu (personal communication, 2016) describes how a journey is created with a linear arc. In this way, navigation becomes a narrative in a chosen context. He tries to include all movements contextually in a constant journey with smooth transitions. The audience flies in and out of chosen locations and then flies to the next destination, rather than jumping from one environment to another. This way the navigational component helps to maintain orientation, because transitions are established between specific locations and the earth’s topography, which can appear very complex at that scale and hence make it hard for the viewer to orient him- or herself.

From a philosophical point of view, Dr Ka Chun Yu's usage of the Digital Earth model inside Uniview enables the recreation of passages and connections that might have otherwise disappeared from the contemporary imagination. The DUA and Digital Earth, nested in Uniview or other applications, have an inherent navigational component that directly influences our storytelling. I suggest looking back at the development history of Uniview by Carter Emmart, Hayden's planetarium Director of Astrovisualization and the SCISS founders, this is hardly surprising, as they were inspired by the continuous zoom of Charles and Ray Eames's classic 1968 film *Powers of Ten* (see subsection 1.3.1).

2.4. Conclusion: The Ongoing Evolution of "Le Passage"

The evolution of "Le Passage" from a flat screen rudimentary cosmic zoom concept in *Powers of Ten* to a passage inside an existing, virtual space of the DUA displayed inside a fulldome theatre helped to develop a unique knowledge instrument. It is especially effective when used to zoom from the earth to the borders of our knowledge of the universe. Within that passage, whilst travelling we experience an in-between space inside which we are open, sensitive, vulnerable—and anything can happen. Abstract knowledge transforms into experienced, embodied knowledge. We not only see new perspectives on relations, but also move through them. However, intimacy and sensitivity are often missing from that movement, because the motion of the camera is left to the automatic technical interpretation of the system itself or, even worse, to an untrained space pilot with a joystick at hand. This illustrates that there is still potential to learn even from the early techniques of the subjective camera, or the

Entfesselte Kamera — or “unchained camera” technique (please see Chapter 5.5.4 for more information).

Systems such as the DUA, Google Earth, Google Earth VR, and *Powers of Ten* allow scalar travel in a way that allows us to envision space. Some of these tools not only illustrate “scalar thinking,” but also the “interconnectedness of entities” (Tong, 2014, p. 206). Especially *Powers of Ten* expanded upon the interconnectedness of entities through their concept “10 by 10.” Tong (2014) concludes that the concept of *Powers of Ten* functions as an intermediary, as it connects the observer with the observed. In his words: “Powers of Ten connects us to a myriad of entities such as strawberries, the Earth, galaxies, humans, cells, DNA, atoms, quarks, and so on” (p. 206).

My question is how much further this interconnectedness of entities—meaning a net of interrelations—can be strengthened through visualisation. What role could the IDE play? The IDE itself could be used as the intermediate membrane—a sort of instrument containing the object of observation, functioning as a microscope, in comparison to the macro-scope, which is already in use via the DUA, yet still requires improvement. In the IDE, the audience could be led through a carefully chosen zoom passage with a time and space constraint, and many in-between layers of spatial knowledge and relations.

After all, we are creating these passages for human beings and not, for example, flies, which can perceive hundreds of images per second, or other creatures, such as frogs, which can perceive really fast movements in full 360° vision due to the

arrangement of their eyes. Rather, the human sensory system needs to be guided through the 360° visual. Similar to architecture, the human being should always stay within the concept of creation, because otherwise the visualisation per se becomes strongly unhuman, abstract, and thus unperceivable. All these aspects need to be applied to the creation of virtual spaces, and even more so when passages are being created.

From a conversation with two aeronomists, I also learned how whole research fields are underrepresented in the DUA, in this case regarding the different layers of the atmosphere or geomagnetic storms causing auroras, which would lend themselves well to volumetric depiction. Thus, for the future one can think about adding more visual information—information that can then be experienced through a passage, for example, moving through the different layers of the atmosphere. Another direction would be the one proposed by Dr Michael Rietveld (heating senior scientist at EISCAT and former researcher at the Max-Planck-Institute), namely to design passages in the DUA whilst using different wavelengths of the electromagnetic spectrum (personal communication, 2014). A passage in infrared would be followed by one in x-rays and so on. When putting images together that have been retrieved from different frequency bands, a lot of information is inevitably lost. However, visual information that is embedded inside an immersive environment, such as the fulldome theatre, can be revealed through a passage experience and in a meaningful context, thus expanding our imaginary. It is therefore worthwhile to think about concepts that would embrace a structure of narrow passages and full spherical environments in order to reach the most intensive representations. Further to this, an immersive environment—because

of its inherent spatial taxonomy and the full 360° peripheral field of vision—can correct and fill in the gaps of incomplete or limited earth or universe model imaginations, whilst offering a concept of spatial passage and transition. This can be seen as a way to prevent the medium from triviality, whilst expanding and opening it up to new media forms.

3. The Paradoxical State of Models and Digital Spaces

Whilst in the previous chapter the main concept of Le Passage was elaborated, it became clear that a world model needs to be there in the first place, so that passages can be performed. Therefore, this chapter delves into the world of models and especially their ability as active instruments to generate new knowledge **and empower digital spaces**.

The paradoxical state of models, their unsolved condition of being—true or vacuous—is extremely thought provoking. Especially since one of the main functions of any model is to make visible, and thus more tangible, what would otherwise be invisible. Models are so powerful when used for visual representation that, when employed in the transmission of knowledge, they are understood as being real, or presenting an exact facsimile of reality through the preeminent evidence of sight.

However, models are also problematic: they are often regarded as artificial, accused of a naive simplicity, or even of falsely representing reality. Professor Mike Phillips addressed this difficult situation in his presentation at the Models of Diversity Conference in Zürich, 2016, suggesting that in our post-ocular transdisciplinary culture, there now exists a significant need to constantly re-negotiate both the fragility of meaning, and the notions that govern those

disciplines that strive to represent reality. Phillips expressed his concern for how easily falsifiability can slip into our models and visual representations.¹ Therefore, the need for a kaleidoscopic and interdisciplinary approach to the representation of natural phenomena that we are trying to make sense of acquires an urgent significance, allowing multi-perspective insights into a given phenomenon, rather than leaving the modelling process to only one specific scientific group, and consequently only one perspective. Crucially, models can be the sole unifying element or the only common feature standing at the intersection of various disciplines. This chapter will thus try to clarify the status of models, both to find answers to the above issues and to illustrate potential approaches to solving these problems. The chapter will seek to expose the inherent value of models, foregrounding their strengths—that is, when used correctly.

The construct of the “model” has been underestimated by the natural sciences in favour of theory for centuries. Theory has always been prioritised, a dynamic that has been less than helpful in realising the real potential of models. The model has traditionally been little more than an accompanying, additional, and sometimes supportive proof for theory as such (Morgan & Morrison, 1999). Only from the 1980s onwards, have models become acknowledged as independent tools in the philosophy of science (Thalheim & Nissen, 2015, p. 37).

¹ This concern has a long history in the philosophical tradition, captured by Jean Baudrillard ([1981] 1988) with the Latin term *simulacrum*.

However, the question is whether a model is not also a medium in itself; a tool, an autonomous agent that produces knowledge on its own, without being dependent on theory (Morgan & Morrison, 1999). Christine Blättler (2012/2013, 2015) suggests that models want to display something by intervening and designing. By doing so, they become themselves exemplary and the process of modelling acquires a new meaning (Blättler, winter semester 2012/2013). This is the case especially when the modelling process takes place in an interdisciplinary context, for example at the intersection between the arts and sciences. Especially worthy of note is how epistemic insights may emerge during the transitional state—on the way to the final product or the final model—insights that may be hidden in the final state. My interest centres upon what constitutes a successful visual model—one that establishes itself in culture and society and is perceived as doxic, as opposed to mere artefact.

The constructivist epistemology states that humans, scientists, and actors do not merely depict the world, but construct it through the process of knowledge production. This line of thought can be traced back to the Greek philosopher Heraclitus. As Plato remarked in his *Cratylus*: “Heraclitus, I believe, says that all things pass and nothing stays, and comparing existing things to the flow of a river, he says you could not step twice into the same river” (402a = A6, as cited in Graham, 2015, “3.1 Flux”). Meaning that no matter how much effort the different disciplines of the natural sciences make to depict reality, they will never succeed in depicting the real world, because the world itself is in a constant flow. Or, as professor in media pedagogy Heidrun Allert and research fellow Christoph

Richter (2015) put it: “We act and analyse inside an unfinished universe” (p. 51, translation mine).²

Moreover, according to both social and scientific constructivism—supported by amongst others Thomas Kuhn (2012) and Karin Knorr Cetina (1999)—scientific practice is driven by collective thought (*Denkkollektiv*) as well as the particular line of thinking proper to a specific discipline or a group of individuals. This argument is further advanced by Paul Watzlawick (1980) in his publication *Invented Reality: How Do We Know What We Believe We Know?*, and finds its analogy in Protagoras’s work and his believe “that each individual human being is the measure of all things” (Stanford Encyclopedia of Philosophy, Gottlieb, 2007).³ Following this strand of constructivist epistemology, especially the natural sciences develop specific human activities to intervene in the world in order to proof that their models represent reality (Collin, 2008, p. 26). Therefore, constructivist epistemology can be understood as a form of *Instrumentalismus* (Collin, 2008, p. 27), using theories, terms, and tools to master reality. These can include not only material instruments and tools, but also abstract instruments, such as the geodesic system divided in longitude and latitudinal lines, projecting a coordinate system upon the earth’s surface, allowing us to measure and navigate the earth (Collin, 2008, p. 27).

² German original: “Wir handeln und untersuchen in einem unfertigen Universum.”

³ Retrieved from <https://plato.stanford.edu/entries/aristotle-noncontradiction/>

As suggested previously, models vary from discipline to discipline: they can be models of the earth, created to simulate climate scenarios, the solar system, the DNA model, or abstract mathematical models.⁴ The central question is: when can a model be defined as epistemic and valuable to both knowledge and society? Regarding the process of modelling itself, this chapter will also analyse how models can integrate with each other; how they can be continuously expanded to encompass new insights; and how they can be supplied with new data to keep them up to date. Since knowledge itself exists in a fluid state, models need to be dynamic in order to access and express this fluidity. Would such a dynamic model not be much more valuable than a static theory or concept as found in text form—for example in school books? Additionally, if a complex model is constructed from others, the question arises how to transition from one model to another, and what characteristics such a passage could obtain. This has been elaborated in Chapter 2 of this dissertation.

The IDE (Immersive Dome Environment) will be used as a means by which to explore these questions. The IDE is a pivotal object of investigation, by virtue of its historical classification and its immersive capabilities, whilst also considered an active instrument. As a model, the IDE produces knowledge, whilst simultaneously guiding artistic language (see Chapter 4 for more information). The IDE itself is in a transitional state, moving from a historical planetarium

⁴ Further, according to Thalheim and Nissen (2015), models can be classified via their various, contextualised uses as follows: Situation-model; perception-model; real-model; explanatory-model; experimental-model; formal-model; mathematical-model; simulation-model; emulation-model; replacing-model; representational-model (p. 9).

environment to a new knowledge producing space—or even a non-space—enabling unique and engaging forms of media art and scientific communication (see Chapter 6 on future 360° concepts for more examples).

As a successful example, the first star projector—a planetarium model with the ability to simulate the starry night sky, produced by the German engineer Walther Bauersfeld (see also subsection 1.1.3 of Chapter 1)—will be investigated, as well as the subsequent Digital Universe Atlas (DUA) model, now being used in nearly every fulldome-planetarium around the world. Using the three-dimensional universe model as a starting point, the chapter will examine how the original aim of allowing insights into unperceivable phenomena is being fulfilled today. Finally, the chapter aims to expose how, and if, the taxonomy of a successful model—by using all the new visual simulation technologies now available—has changed and if so, whether any change has resulted in a better, or indeed worse, epistemic function—a subject that will be further elaborated in Chapter 4.

3.1. Defining “Models”

Historically, the term “model” developed during the Italian Renaissance to the word *modello*, meaning “pattern” (*Vorbild*), “sample” (*Muster*), or “image” (*Abbild*; Quack, 2007). The scientific model is a physical, conceptual, or mathematical representation of a real phenomenon that is difficult to observe directly (Kara Rogers, 2011). The Kieler School compares the term model to a proxy, which through its simplification enables an examination with an object or process (Thalheim & Nissen, 2015, p. 29). In French, it is also referred to as a *maquette*, meaning a smaller scale model of a sculpture or

building. The term “model” is extensively used these days and is a fiercely debated topic at academic conferences, such as the Models of Diversity Conference in Zürich, 2016, with particular regard to the representational qualities and influences of knowledge formed by models, since models “are one of the main instruments in scientific research” (Thalheim & Nissen, 2015, p. 3). Often these debates occur between disciplines that do not share a joint understanding of the term model—or at the very least do not share the same image and context of a given model. These incongruences of attributed meaning are responsible for many misunderstandings.

Therefore, since the term is being used in various disciplines—such as agriculture sciences, archaeology, fine arts, biology, chemistry, electrical engineering, geology, history, informatics, climate science, linguistics, mathematics, medicine, economy, pedagogy, philosophy, physics, political sciences, sociology, science of sport, and environmental sciences (Thalheim & Nissen, 2015, prologue)—there is a need for a valid interdisciplinary definition of the term “model.” In the case of the IDE, various disciplines tend to collaborate in order to develop a single visual piece, subsequently shown in the digital planetarium for science communication purposes. For these teams especially, a shared conceptualisation and taxonomy of the term “model” would be very beneficial.

Bernhard Thalheim, professor in computer science, and computer scientist Ivor Nissen (2015) recognise the need for a general definition. In their book they point out that different disciplines have developed different understandings of the

notion, function, and purpose of models as determined by their specific fields of research (Thalheim & Nissen, 2015, p. 3). Their intention is to elaborate a systematic approach to the term model, which can then be used in an interdisciplinary context, spanning the disciplines as a way to understand, build, and use models. The authors outline the following definition:

A model is a well-formed, adequate, and dependable instrument that represents origins. Its criteria of well-formedness, adequacy, and dependability must be commonly accepted by its community of practice within some context and correspond to the functions that a model fulfils in utilisation scenarios and use spectra. As an instrument, a model is grounded in its community's sub-discipline and is based on elements and paradigms from that sub-discipline. (Thalheim & Nissen, 2015, p. 9)

To help clarify and hopefully validate this definition, the example of the first Bauersfeld planetarium in Jena, 1923 will be briefly examined.

The model of the Bauersfeld planetarium with its hemispherical cupola and star projector is well-suited to the specific purpose of star projection, and it is thus a dependable instrument, displaying the stars in their exact positions, and representing and simulating with accuracy the starry night sky. The planetarium's operating criteria are approved amongst astronomers and astrophysicists alike, and are thus commonly accepted by its associated scientific community as representing best practice. Many planetariums around the world bought the Zeiss star projector and used it in their specific scenarios,

such as science communication to the public, or for research and teaching at their planetarium facilities. The planetarium model was also based on elements from the sub-discipline of astrophysics, including elements such as Kepler's laws (see the original patent document in the Appendix).⁵ The planetarium model needs to incorporate such laws in its simulations and representations in order to be valid and accepted by its community of practice. Therefore, the definition above can be used and fits the understanding of a model in this field of research.

3.2. Models in Their Transformation Process

As Martin Quack (2007) professor in physical chemistry points out, models are not a one to one copy, but rather a simplification, a scaled down version, or simply a transformation from the original. It is in this transformation process that the real potential of models resides, making them more—rather than less—valuable than if they were simply a copy of the original. For this reason, of particular interest is what exactly happens in the process of transformation—something discussed in more detail below.

According to philosopher of science Jürgen Mittelstraß (2005) models are replicas of either a real or imaginary object, with the primary aim to either directly aid, or assist, learning. Our perception system cannot directly access the object in the physical world; the object can only be represented through the

⁵ Johannes Kepler developed three fundamental laws regarding the motion of the planets, namely the laws of orbits; areas; and periods (Bauersfeld & Villiger, 1927).

model. This is true of both the non-scientific and the scientific world. Therefore, the model then represents our only access to the object of investigation.

This makes it even more important to study more closely the process of transformation from objects to models. Here, there are two aspects that need to be emphasised:

1. *Vereinfachung*—the simplification of complex structures as within astronomy, the armillary spheres;
2. *Anschauung*—the illustration of abstract structures as within physics, for example in a model of an atom. (Mittelstraß, 2005)

It is important to note that there are also models that work the other way around, making the object appear more complex. Such models can be found, for example, within the disciplines of logic and mathematics. However, these models lie outside the scope of this research.

Next to a logical-mathematical model, one can also differentiate between a scalar model, an analogue model, and a theoretical model. Scalar models are scaled up—or down—“duplicating” real or imaginary objects, such as in the scaled up model of a fly (see Figure 3.1). A theoretical model consists of many assumptions and equations, which are meant to cover substantial properties of an object or system (Mittelstraß, 2005).



Figure 3.1. Fly and DNA , by Mike Phillips, 2012, Medical University of Plymouth. (personal communication).

One should also be aware that models can easily be misunderstood as oversimplified. However, I suggest that it is exactly this simplification that sometimes provides the additional value of models, proving general functions and relations that would be difficult to recognise in the complexity of the original (see chapter 4 for more information). In the following subsection, the history of models and original forms of three-dimensional physical models as used in the sciences will be considered along with their particular values.

3.3. An Archaeology and Taxonomy of Models

3.3.1. Models in the Past and Today

Models have, from their earliest beginnings, attempted to bring the tiny, the huge, the past, and the future within reach. This they have done through wooden

ships, wax embryos, and mathematical models (Hopwood & de Chadarevian, 2004). In their remarkable book *Models: The Third Dimension of Science*, Nick Hopwood, professor of history of science, and medicine and philosopher Soraya de Chadarevian (2004) specifically examine the inherent qualities of three-dimensional physical models—since it is through this feature that they can display relations that otherwise could not be seen via a flat, two-dimensional medium. The authors explain the important way in which the manufacturing and subsequent display of models in museums or exhibitions such as the Great Exhibition of 1851 became a key medium of traffic between the sciences and wider culture (Hopwood & de Chadarevian, 2004).

Similar to the Great Exhibition, contemporary planetariums and museums are still using visual 3D models of the earth or the cosmos to portray the newest scientific data and thus communicate that data to the general public. Models maintain a powerful position within science communication and culture, both within planetariums and beyond. This is achieved by combining models with new visualisation technologies, such as satellite imagery; the earth model used by Google Earth; and microscopic photo geometry scans used for microscopic models, such as the model of the fly in Fehler! Verweisquelle konnte nicht gefunden werden..

Models are not reality. Rather, they try to represent one tiny part of a possible reality. Thus, there might be several prospective approaches to a given representation. For example, some models employing mixed scientific data—

whilst partially using correct data—may nevertheless lack internal structure,⁶ be partly incorrect, or assembled in the wrong way. Contemporary narratives of data overload and technological development that allow us to incorporate data automatically through software in various forms enable the creation of models much easier than was previously possible.

Further, these innovations have led to the evolution of new, hybrid models. 3D software such as Autodesk 3Ds Max as well as open-source 3D software enable textures gained via satellite images to be used to cover spheres in order to represent earth. As one of the most common scenarios displayed in the dome environment, physical constraints can be applied and simulation tests can be run and re-run until the final settings are exactly correct and, for example, the earth rotates how it should, or climate scenarios are being played out.

Importantly, depreciation can occur, similar to the way in which the ongoing process of creation, deconstruction, and re-creation of digital maps can decrease the meaning and value of maps, causing a lower orientation and declining spatial memory (see also subsection 4.1. of Chapter 4). The same can happen to data models. So how can models with true explanatory power be distinguished from 3D models made by amateurs and private individuals using the same 3D software? And how can a Google Earth Model be different from a self-made 3D model of the earth? Is not the only difference the data input, varying from satellite imagery to the photos of individual users taken on a

⁶ The Google Earth model, for example, is a hollow sphere: it is mapped with textures from satellite images, but there is no inner structure.

specific location, or their own software SketchUp models of buildings uploaded to Google, for instance? In view of these various narratives of creation it is interesting to analyse how such models are realised—how they are used and presented, what effects they have on the public, and more generally speaking, on the production and communication of knowledge.⁷

3.3.2. The Explanatory Power of Models

The explanatory power of a successful model can be quite striking. Models can represent tools from which whole societies can learn in order to gain a better understanding of the world. It is important to note that the medium of the model itself also informs the ways in which we “know” the world to be—science constructs the world for us in specific ways; the theory of constructivism (see the introduction to this chapter). The longitude and latitude of the globe represents an often recalled example: We all use this method of segmenting the earth, but rarely reflect on the fact that it is in fact a human-made model—albeit one that is well established in society and culture, and is universally taught in schools (Collin, 2008, p. 27). Other models, such as science-based worldviews manifested through astronomy and astrophysics, establish new signs and symbols that are both understandable and applicable (Abel, 2008). Whole societies and cultures orient themselves towards such models, such as representations of the magnetic fields of the earth, gravitational waves, galaxy collisions, tornados, and climate scenarios.

⁷ Further remarks on the topic: The Model of the Quantified Self: The Human Model can be find in the Appendix due to the word count of this thesis.

In the following section, I will analyse and clarify the definition of the term model—its meanings and capabilities—through engagements with different disciplines. As will become apparent through this analysis, my main questions are: When can a model be defined as epistemic and valuable to the production and the transmission of knowledge, and which taxonomies does it need to fulfil in order to achieve this? When does a model produce knowledge on its own? Models that have the unique capacity to enlightening specific phenomena — phenomena that would otherwise not be perceivable—will be foregrounded in this analysis.

3.3.3. Model – Theory – Reality: A Dynamic Relationship

There exist very particular connections between any given model and reality. This relation is two-sided: the model can either be created from the image of an already existing reality, or a certain reality can be materialised after a model, such as is the case with an architectural miniature of a building (Quack, 2007).

In relation to theory, a model can function in two ways. Firstly, it can be developed in the phase of cognition/realisation, in which there is no prior knowledge or theory about the phenomenon:

Observed Facts \uparrow Model \uparrow Theory

Or, if a full theory of a given phenomenon is available, the model helps to simplify and therefore grasp the reality of that phenomenon:

Theory ↑ Model

As stated earlier, models are transformations and not simply copies of reality. Thus, they do not function to mirror reality through a complete and correct image, but rather emphasise specific aspects thereof. A good model is a simplified image of reality (Quack, 2007). This simplification can perform a powerful function, potentially opening the viewer up to a new mental framework, and making complexity available and controllable through reduction. This way, models can be sources of subtle steering, either shifting, or narrowing, the boundaries of the problem (Bredekamp, 2007).

Since paradoxically, models themselves are part of the real world, their usage needs to make connections between different objects of reality apparent, thus making reality itself more understandable. However, one should take into account that simplification and reduction also present an enormous risk of misinterpretation, especially if several working groups are involved in a project. Therefore, models need to be explained and used with caution—even more so when presenting and explaining models to the general public.

3.3.4. The Model as Autonomous Agent

In the article “Models as Mediating Instruments”, Margaret Morrison (1999), professor of philosophy, and Mary Morgan (1999), professor in history and philosophy of economics, stress that models in their various functions occupy an autonomous role in scientific work—a function that is closely connected to their ability to function

as instruments. “It is precisely because models are partially independent of both theories and the world that they have this autonomous component and so can be used as instruments of exploration in both domains; world and theory” (Morgan & Morrison, 1999, p. 10). This specific property of models can also be called their *‘Doppelgänger’* ability: they have the potential to act in reality as well as in the theoretical domain (Morgan & Morrison, 1999). Thus, what exactly is that autonomous component and how can it be useful in the process of enlightenment or knowledge production?

Morgan and Morrison (1999) propose an answer to this question through their consideration of the construction process. It is very often believed that models are derived completely from theory or data. However, if one looks closely, they are neither only theory nor data, but always involve outside elements. The process of model construction, for example, also involves creativity, and some claim that it is not a craft so much as an art. A good example of this is the work of molecular artist and former architect and illustrator Irving Geis, who, similar to his Renaissance predecessors, used art to teach the public new findings in “molecular anatomy” (Dickerson, 1997).

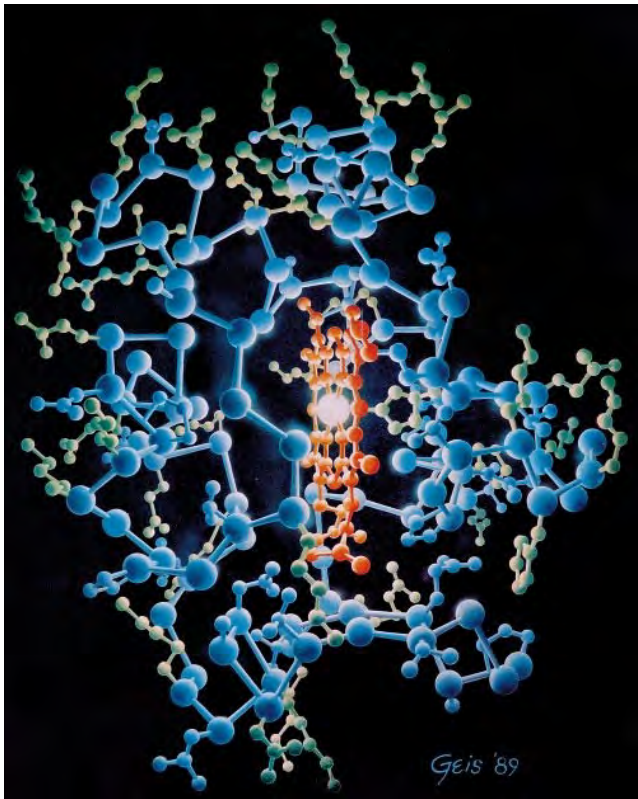


Figure 3.2 One of Geis' two 'molecular lantern' paintings of horse heart cytochrome. From Dickerson, 1997, p. 1248

Geis's drawings involved a laborious process, in which he travelled to the model, took photographs from different angles, and proceeded with sketches until he finally conceptualised and painted the final drawing (de Chadarevian, 2004, p. 350). In his works, Geis used the concept of "creative lying," by which he understood the introduction of small distortions or increases in scale that could emphasise or resolve overlaps and thus create an understandable image irrespective of complexity (Gabe & Goodsell, 1997).

One of Geis's colleagues, the biochemist Richard Dickerson, writes that Geis "taught us [the scientists] all how to look, how to understand and how to show others what we saw" (Dickerson, 1997, p. 1249). This begs the question: Is this transformation process now science communication? Is it art, or is it a mixture

of all these components, moving towards the development of a certain “art of understanding”? To learn more about this concept and approach, see Chapter 4.

3.3.5. Creativity

Creativity is needed whenever a story or concept needs to be created, an excellent example being Stephan Harmann’s MIT-Bag Model of quark confinement. The choice of which components should be included in the model resulted from an examination of how quarks exist in nature (Morgan & Morrison, 1999). Another good example of what the process of model construction can encompass is given by Marcel Boumans, Associate Professor of Philosophy and History of Economics, who analyses the building of a mathematical model of the business cycle. According to Boumans (1999), models are built via a process of choosing and integrating a given set of items. He refers to

bits of theories, bits of empirical evidence, a mathematical formalism and a metaphor which guided the way the model was conceived and put together. In that constellation by combining all elements into one language [here: mathematics] provided a solution that could otherwise not be achieved. (Bouman explained by Morrison, 1999, p. 13)

Thus, a mathematical model can act independently of theory or data (phenomena), and can thus possess autonomy. Further, models are being used as instruments with which to explore and experiment with various theories—or even to correct a theory that has been in existence already for quite some time (Morgan & Morrison, 1999, p. 19).

All of this highlights how models can exist independent of any specific theory:

The power of the model as a design instrument comes not from the fact that it is a replica of the object to be built [but] from the fact that they [models] provide the kind of information that allows us to intervene in the world. (Morgan & Morrison, 1999, p. 23)

A model can thus be used not only as an instrument in its own right, but also as a tool for design and intervention.

3.3.6. Models and Spatial Representation

Models and their representational capabilities have their specialties—most notably their three-dimensional spatial representation properties—through which they can display relations that could not otherwise be represented through a flat medium, such as paper or a screen (Hopwood & de Chadarevian, 2004). These properties allow observation from different angles and, in view of these properties, they can in some ways be better categorised as spatial representations. Another important aspect is the manipulation of perspective. Through these manipulations one can, for example, spin the model and get various insights from different viewing angles—a multidimensionality.

Further, as well as the ways described above in which objects can be manipulated, they can also be taken apart and re-assembled, revealing complex spatial relationships. Models are thus often used, not only by scientists for

experiments, but also as learning aids (Hopwood & de Chadarevian, 2004).

Another example are new anatomical organ models, which are realised through 3D printing. These models even have the ability to bleed if scratched too deeply in an operation training exercise. They are thus ideal for medical teaching purposes (Witowski, 2016). It is important to note that the greatest learning potential can be found in the construction or building of a given model, or later from using it and observing the effects. For this reason, active models are the most appealing (see Chapter 6 for possible usage scenarios for such models).

As mentioned earlier, models open new mental frameworks through both simplification and transformation, but they can just as well introduce novel virtual structures or orders, allowing a new or wider context. “In a few cases of information systems, the real spatial relations are not as important as the virtual ones: a virtual order is instituted, replacing the real one” (Kyriakoulakos, 2011, p. 1). One of the strongest tasks that can be fulfilled by a model, however, is model-world representation. For example, this can be a 3D simulation model with satellite data to illustrate real-time data coming in from a special event—such as a tornado—showing its dimensions, appearance, and effects on land. In such a representational framework, climate scenarios can be elaborated by testing and showing, for instance, the effects on water supply systems or water quality.

In the show “Earthquake: Evidence of a Restless Planet” (director Ryan Wyatt, 2012) of the California Academy, for example, there is a sequence that illustrates the effects of an earthquake in the city of San Francisco. By zooming out, the

effect of the earthquake upon the whole California Coast can be observed, and even its effects on the planet. The city is a 3D model, in which the simulation of an earthquake was run and then rendered as a film sequence in order to be integrated into the whole 360° film. This example clearly demonstrates that the simulation and the model of certain phenomena are inherently linked: a model can inherently possess the capability of simulation, and it can be generated by computer simulation which develop the affinity for hyper realistic models as philosophy professor Christine Blättler (2015) points out (p. 127). The following section will examine if the taxonomy of a successful model has to include the capability of simulation.

3.4. Models and Simulations

The term simulation comes from the Latin word *simulare*, meaning to fake or false pretence (Keller, 2002)⁸—a meaning that was fortunately replaced by a more neutral and productive semantic. As Evelyn Fox Keller (2002) professor emerita of history and philosophy of science puts it, simulation is now understood as “designating a technique for the promotion of scientific understanding” (p. 198). The term is used for any reproduction of physical, biological, social, or economic processes through models. These models enable harmless and non-destructive analyses and application. The Association of German Engineers (2016) defines “simulation” as follows: “Reproduction [*Nachbildung*] of a dynamic process inside a model, to gain insights, which can then be applicable to reality”

⁸ As mentioned previously, the term “simulacra” was used extensively by Baudrillard ([1981] 1988)

("Produktionssystemen Simulation und Optimierung", VDI-guideline 3633, translation mine). It is important to distinguish between a model and a simulation. "Models constrain the kinds of behaviour that can be simulated," whereas simulations can provide knowledge of models and physical systems (Morgan & Morrison, 1999, p. 29). If a model can simulate behaviour providing knowledge of the model itself and the physical system, then a model should be regarded as an active agent in the production of knowledge. R. I. G. Hughes (1999) further states that a model may in fact provide a good explanation of the behaviour of the system without necessarily being able to faithfully represent that system. Therefore, the model functions as an epistemic resource: "We must first learn what we can demonstrate in the model before we can ask questions about real systems" (Morgan & Morrison, 1999, p. 33).

3.5. The Philosophical Term "Model" in Conjunction with the Immersive Dome Experience

My philosophical focus with regard to the concept of the model encompasses both the technical and epistemic aspect of modelling. Specifically: how can a model and the immersive qualities of the IDE be combined for an enriched and lasting knowledge experience? The following section will investigate how the planetarium became a model with the ability to simulate the night sky, questioning whether that simulation reveals a quality—a model function—that can be regarded as an epistemic resource.

In October 1923, Walther Bauersfeld filed the patent licence for his “device for projecting stars” see figure 3⁹ in the US. The patent license describes precisely the movement of the planets in relation to the sun following Kepler’s laws (something already known by Christian Huygens in 1642), realising the motion via a gearing mechanism (Krausse, 2006, p. 58).

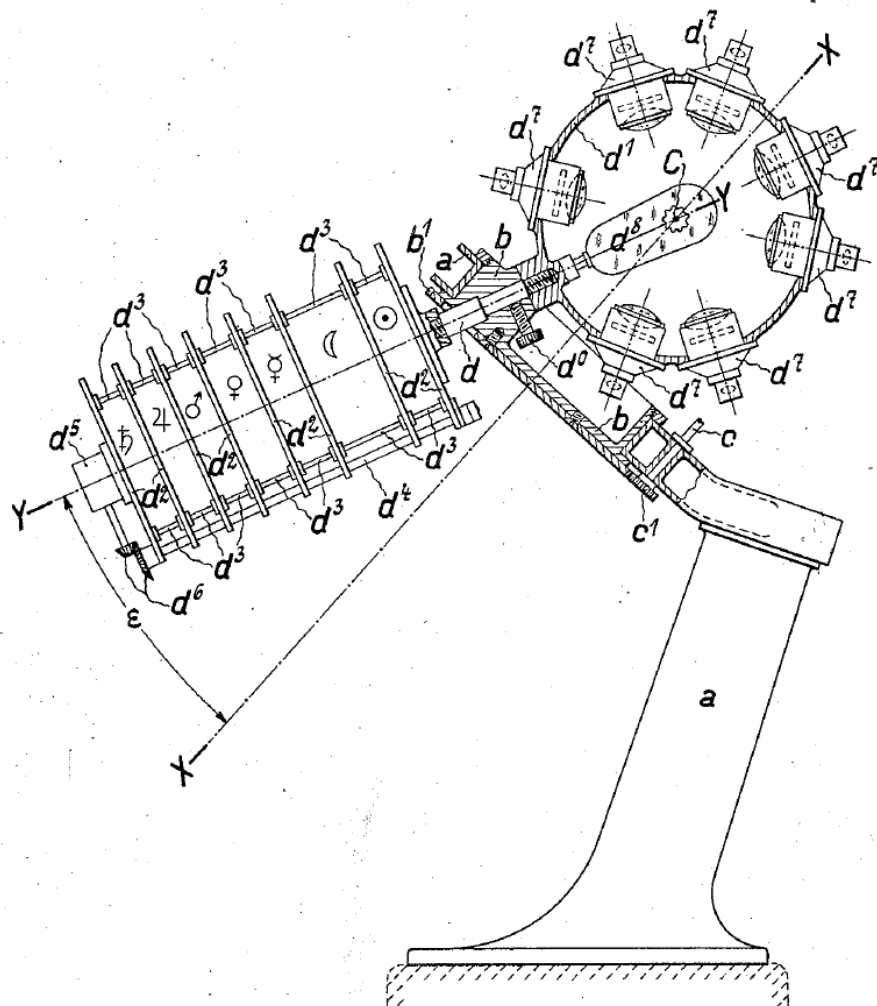


Fig. 1

Figure 3.3 Device for projecting stars. Zeiss Model 1. Drawing of Stellarium, patent license, Bauersfeld & Villiger, 1927

⁹ A copy of the original document can be find in the appendix.

However, it was only through a combination of the stellarium and the planetarium that a full time-space simulation could be reached, allowing day and annual time lapses (as shown in Figure 3.3). This meant that an entire day could be run in one minute—a full rotation of the earth and therefore the movement of the whole sky, as well as an annual movement; a full orbit of the earth around the sun. For annual movements, the daily rotation around the earth's own axis demanded very precise work (Levin, 1926). The classic planetarium model was thus created in order to make the otherwise unclear complexity of a natural phenomenon accessible to human perception through experimentation. Bauersfeld's intention was not the creation of a painting, but rather the creation of a spatial view (Levin, 1926).

It is an interesting question as to whether Bauersfeld and his companions had the encompassing effect of a 360° canvas in mind, or whether it was a fortunate but unintentional result, arrived at whilst trying to simulate the night sky in a spatial context, using the full scope of human perception by transferring it to the cupola setting. The planetarium with its star projector had several predecessors, and a dome ceiling was born—for instance the one in Munich, which employed a flat image see figure 4.

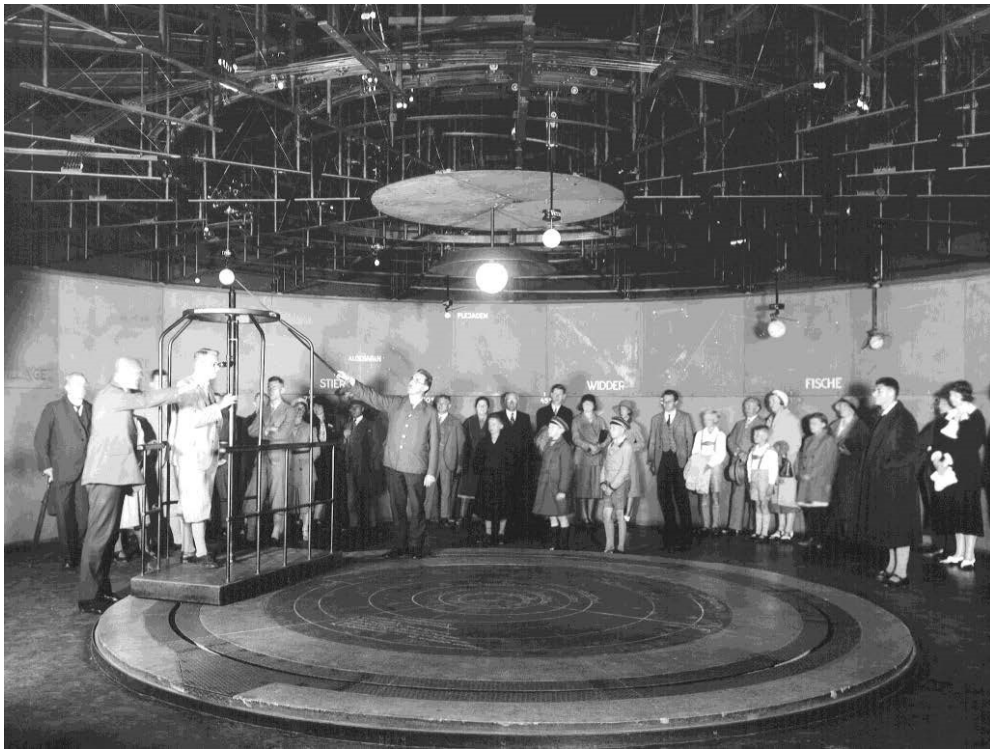


Figure 3.4 The Zeiss Copernican Planetarium (Deutsches Museum, 1924).

Yet the IDE still carries its original context, which goes back to Bauersfeld and the traditional planetarium setting. The 360° dome medium is even seen as an “old” concept—simply a modern incarnation of a traditional planetarium setting. However, this view obscures the possibility that it can be a unique, hybrid media format that opens new ways of perception and goes way beyond the old planetarium concept. It combines elements of traditional planetarium instrumentation with real-time aesthetics, cinematic language, and interactive possibilities to create new visual concepts. These aspects—from its origins and inherent aesthetics, to its unique characteristic of cognitive faculty, all of which unfold inside the 360° projection space—will be explored further in subsequent chapters.

3.6. Conclusion: Models

Regarding models in general—the main elements of investigation in this chapter—it can be said that successful models should no longer be seen as “preliminary theories” or objects under glass from the last century, but as essential ingredients in the process of knowledge production and communication. Models are active instruments in the generation of new knowledge, also when they are expanded into the digital space.

A solution to the uncertain state of models and their precarious position with regard to the substance of truth might be resolved by the following taxonomy of a model: transparency in the transformation process of modelling, including creative and autonomous components, amongst which simulation capability and pure data input, making the perception of truth dynamic, interactive, fluid, and adaptable to new insights. Through the visualisation process, a connection to our body and personal space should be created, potentially resulting in new experiences and perspective shifts.

These perspective shifts can be assisted and even expanded by using an interdisciplinary and kaleidoscopic approach to visualisation. Creating models that fulfil this dynamic character is a new challenge. Yet, would a model that is adaptable, dynamic, and always open to questions yet to solve not be more truthful to our ever-changing and expanding realities than any static model or image used in schoolbooks today could ever be? Significant value exists in the practice of modelling, specifically in the fluid state and dynamic nature of models—their contemporary relevance and potential future growth into digital spaces.

3.7. Digital Space: The Validation of the Virtual

The following chapters aim to clarify the scientific validity of virtual spaces, questioning whether we lose the authenticity of the "real" physical environment inside the digital space or, on the contrary, gain knowledge.

I understand a virtually constructed space to be even more valid than "real" space in terms of perception.

First, I illustrate this by comparing photography with virtually constructed spaces via 3D geometric scanning. I further deploy my own case studies in order to compare 2D and 3D creations of virtual spaces for the IDE. In the second part of this chapter, the inclusion of spatial data is investigated, as well as its various effects on narrative development and the way in which a given story is told—especially in immersive dome environments. A space needs to be navigated. This navigation needs to be planned carefully, including timing, speed, and the perspective on the spatial data that is being shown. Therefore, navigation becomes a key component in creating the narrative. In the third and final part of the chapter, "Passing by Flying Through Digital Space," an examination of the production of scientific visuals and their use as spatial experiences or vehicles for knowledge within the IDE—specifically in the fields of astronomy and geography—will be presented.

The overall question is whether text is the most adequate format in which to store knowledge, or if visual formats—specifically as digital spaces—are more suitable by virtue of their richer repertoire of epistemological properties—such as the scalable universe—to be the new knowledge containers. Simultaneously, I

suggest digital spaces as the interdisciplinary intersection between academia, art, and technology—spaces where artists and scientists can meet, create, and exchange.

3.8. The IDE and the Conquest of Space

3.8.1. The Historical Roots of the Coordinate Space

The spatial component is quite natural to the IDE, specifically if its planetarium roots are being consulted. When looking back to its history, it is important to mention that Bauersfeld's intention was not the creation of a painting, but rather the creation of a spatial view (Levin, 1926; see also subsection 1.1.3 of Chapter 1). According to writer and violin-maker Julius Levin (1926, explained in von Herrmann, 2018), the planetarium implies an artistic effect without an artistic will. For Levin, the planetarium is a technical exhibition room and poetic space of illusion. Most importantly, L. Moholy-Nagy (1929) describes the planetarium as a new phase in the occupation of space (as



Figure 3.5. Extract from *The Birth of the First Zeiss-Planetarium*, Jena, Germany.¹⁰

¹⁰ Retrieved May 4, 2015, <http://www.deutsches-museum.de/ausstellungen/naturwissenschaft/astronomie/planetarium/geschichte-des-planetariums/>.



Figure 3.6. Montreal Biosphère, built by Buckminster Fuller, 1967. Photograph by Isabella Beyer, 2017.

explained in Schramm, Schwarte & Lazardzig, 2008]. The floating, transparent net of Bauersfeld's planetarium (Figure 3.5) and Buckminster Fuller's geodesic dome (Figure 3.6) are capable of holding man free in space, with neither a connection to the ground nor any support. It is enclosing a space whilst simultaneously opening to the outside space, and we can still look through to the outside from different viewing angles.

Metaphorically, the medium can also be understood as a contemporary simulation space—freeing the audience in an imaginative space without any reference to the actual physical environment or, in other words, offering a fully new space for exploration. Whilst in the cupola, the audience effectively adapts to a fully new coordinate space (Remann, 2009, p. 105).

3.8.2. The Coordinate Space as an In-Between Space

This coordinate space can include many informational attributes, and can therefore be considered an important *in-between space* (Mersch, 2011). As I have noted in previous work, “[t]he spatial arrangement of knowledge can be seen as creating a new *in-between space*, as with its specific topological structure, opening the access of arrangement—as patterns and relations that make new associations and connections possible” (Buczek, 2013, p. 226, emphasis in original). This spatial arrangement of visual information enables discovery at first sight, whereas text follows a syntactical order; one after the other. In the spherical visual space of the dome, we can even expand the immediate discovery of the new to a huge 360° immersive space, providing a well-constructed surrounding and expanded space for exploration (see also Chapter 5 on the taxonomy of the IDE).

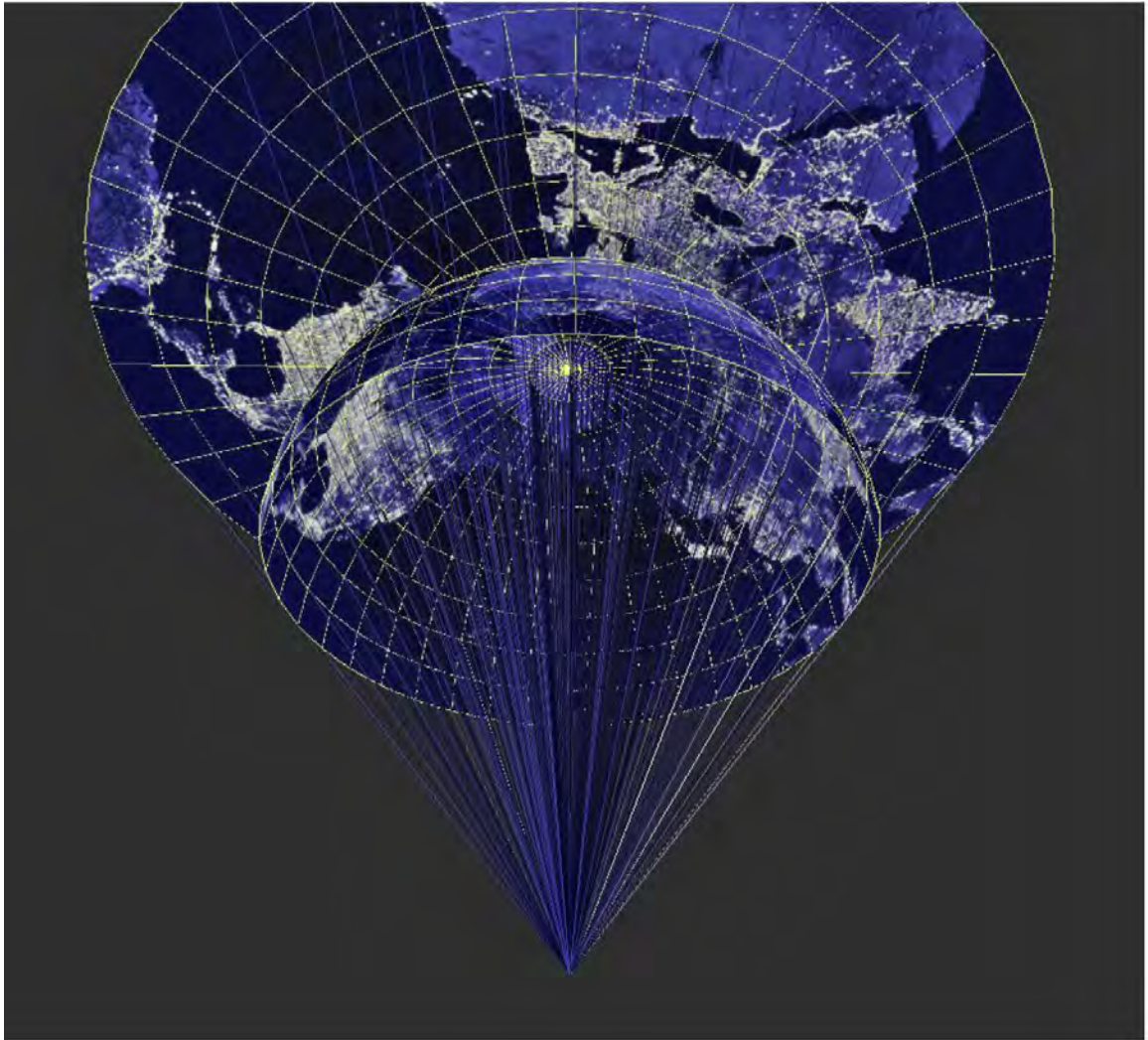


Figure 3.7. Mapping the 360° coordinate space. Software of display developed by Dimitar Rushev, 2010, screenshot Isabella Beyer.¹¹

Inside the IDE of a fulldome planetarium, the content can be manipulated, changed during production, or even whilst being interactively displayed. Further, via new technological capabilities and real-time systems the earth can be visualised from multiple perspectives, using satellite photographs of the earth's surface. These photographs are mapped onto the earth's surface structure within a virtual, programmed space. In Figure 3.7, one can see via the software developed by Dimitar Rushev (2010) how a whole earth texture can be applied virtually to the

¹¹ Satellite image source: <http://visibleearth.nasa.gov/>

inner surface of the cupola, resulting in a spherical environment as it would be seen in the IDE.

The complete map of the earth can exist of more details and satellite images than in Figure 3.7. Especially inside a large dome environment, more resolution and detail are needed. These images can be updated whenever new images are taken by the satellites. This fluent feeding of data via the internet can be in some ways regarded as a living “breath” that adds life to the ever-changing and transforming visualisation of the earth projected onto the dome of a planetarium, or displayed via an online application.

Unfortunately, mapping with satellite images that differ in brightness, contrast, and colour—as they are taken at different points in time—can also cause disorientation, since the audiences are used to seeing the earth in other media as a smooth, contiguous texture. At the same time, it can be seen as a very truthful procedure, since it reveals the making of the visual itself. This makes the visualisation process transparent.

3.8.3. From Simulation Tool to Infinite Space

The planetarium is described by professor of literature Hans-Christian von Herrmann (2006) as a machine for both space and spatial travel in which art, science, and technology are combined in a fascinating manner. Whilst observing the fixed starry sky and the loops of the planetary orbits, the viewer becomes witness to a spectacle that is, according to Herrmann (2006), a poetic “mimesis.” It is often misunderstood as a simulation—or in other words, as a replica—but

rather, the term implies a playful act of illustration through which unclear multifariousness can be made accessible to human perception (Krausse, 2006; for more information on the relationship between models and simulation, see subsection 3.4 of Chapter 3).

The above concurs with the observations of the astronomer Max Wolf (1930), who suggests that audiences show tremendous deficits in their ability to imagine the movement of the fixed stars in the night sky, or the relation between the stars and the earth's rotation. In his view, the main advantage of the Bauersfeld planetarium is the realisation and clarification of phenomena, which occurs during the performance (Max Wolf (1930) cited in Krausse, 2006, p. 59). This property—of spatial clarification—creates the aesthetic conditions for cognitive faculty (see also Chapter 3).

The slow movement of the celestial bodies can be mitigated in the Zeiss planetarium through the manipulation of time. The observation of multiple celestial events can be demonstrated within the space of an hour. Indeed, in this single hour one can potentially gain more knowledge of astronomy than through observations in nature spanning many years. Wolf (1930) points out that with the Zeiss Model II in 1924, the sky has been made accessible for experimentation. One no longer needs to wait for the events in the sky to occur; on the contrary, one can initiate and make them happen. The audience is still very close to nature, but with the possibility of endless repetition, if desired (Max Wolf (1930) cited in Krausse, 2006, p. 59). Therefore, the IDE has historically been a space for experimentation, and continues to be so today.

3.8.4. Beyond the 360° Space: Embodiment and Disembodiment

The focal point at which instrumental realism emerges is the simultaneous recognition of what I have called the technological embodiment of science, which occurs through the instruments and within experimental situations; and of the larger role of praxis and perception through such technologies (Idhe, 1991, p. 99).

Inside the IDE, the projection into the inner surface of the cupola has unique perceptual advantages that cannot be simulated within traditional cinema. According to Carolin Hanisch and Sebastian Bucher (2006), whilst the planetarium offers a view of the night sky, it simultaneously modulates the celestial bodies and events. Through the movement of the star projector, the audience gains the impression that the stars and planets are circulating around the cupola ceiling, although in fact the movement of the earth is being simulated (Hanisch & Bucher, 2006) and the spectator follows the earth in its orbit around the sun whilst staying static in their chair. Therefore, the spatial imaging extends beyond the space of the dome.

The experience inside a planetarium simulation can be described in two stages: At first the viewer inhabits the planetarium with his or her body, looking onto the night sky and being present in the simulation and inside this space. During the second stage, the viewer embodies the movement—when realising one moves inside the planetarium around the sun in an accelerated velocity, the viewer is

travelling on Spaceship Earth¹² inside the planetarium. Once the second stage has been realised, the consciousness shifts and via an *enactive* view, knowledge generation occurs (Varela et al., 1991).¹³ If the spectator succeeds, his or her perception and understanding of the environment changes dramatically. It results in the experience of an embodied movement, and therefore generates experienced, spatial knowledge. It enables one to imagine a space beyond our sensed, tangible surroundings; a space beyond the cupola ceiling.

The viewer learns by interacting with the environment, and learns by doing—here in the sense of a thinking process and subsequent realisation in the mind. In Marieke Rohde's (2010) words: "In the enactive view, knowledge is not represented, knowledge is constructed: it is constructed by an agent through its sensorimotor interactions with its environment" (p. 30). Passage concepts can be effectively used inside the planetarium as a vehicle, as a means by which to achieve this enactive pattern. This is a strong function, since in general, every image input requires processing and interpretation and, I would add, a connection to the human being in order to be converted into knowledge—such as is achieved through enaction and experience (Buczek, 2011; Richelson, 1999).

¹² The concept of "Spaceship Earth" was coined by Buckminster Fuller (1969) and will be further elaborated in Chapter 6.

¹³ Varela (1991) proposes a new approach in cognitive science, which he names *enactive*. In his new view, cognition is outlined as embodied action. He states further that cognitive structures occur from repeating sensorimotor patterns that enable action. Varela proposes to be fully present in one's actions, so that one's behavior becomes more aware. That way he links perception and action very close together as mutually selecting patterns.

The contemporary technology of a fulldome projection allows this experience to be complemented by components that enable spatial relations between the body of the spectator and the surroundings, picking up the members of the audience from average human scale whilst standing on the earth's surface and then looking up towards the night sky. This way the bottom area and the connection to one's own body can be augmented. In traditional star projection planetariums, the bottom of the earth could not be observed—only the stars—so that the earth's surface and distance had to be imagined by the audience.

In the above experience, an *inner* insight, reflection, and localisation, as well as an *outer* reflection of the observed simulation, need to be mastered, and both need to be combined in a unity of body and mind in order to expand the spectator's imaginative vision beyond the dome environment. I will now provide an analysis of how new visualisation capabilities can manipulate the imagination

of real physical space.

3.9. Reality, Manipulation, and Computer Space

3.9.1. Media Materiality

In the light of increasing computerisation, as well as the technological convergence process of media formats, the question is whether the purity of the visual and the validity of space can remain intact. To answer this question, an investigation of media materiality, the production of unusual visual spaces, and spatial as well as emotional concepts, will be conducted.

In his article “Understanding Hybrid Media,” Lev Manovich (2007) investigates the moving image itself, stating:

“computerization virtualized practically all media creating and modification techniques, “extracting” them from their particular physical medium of origin and turning them into algorithms. This means that, in most cases, we will no longer find any of these techniques in their pure original state.” (p.13)

Accordingly, Manovich separates the moving image into objects and their variables, in the same way as the computer software in which the objects are finally rendered. That way he makes an important discovery: every variable and image is in a state of permanent transformation—a permanent metamorphosis (Manovich, 2007). He foregrounds this phenomenon as the general condition of media hybridity today. His statements are based on the analysis of common contemporary media projects and the ways in which they compare to the moving image culture of the 1990s. In addition, Manovich studies the tools and production processes of a selection of contemporary media projects. In software packages, for example Adobe After Effects, each new object added to the scene appears as a long list of variables—geometric position, colour, transparency, etc. (Manovich, 2007). Each variable can be changed and animated, as can be observed in Figure 3.8, presenting my working example for a recent planetarium show entitled “Der dreiäugige Totenkopf” [The Three-Eyed Death's Head] as part of the well-known German audio-drama series “Die Drei Fragezeichen” [The Three Question Marks].



Figure 3.8. Screenshot of my compositional work in Adobe After Effects for the planetarium show “Der dreitägige Totenkopf,” Isabella Beyer, 2018.

Thus, everything inside the circle keeps changing: visual elements; their transparency; the texture of the image; and so on. Also, the display technologies are changing due to improved production possibilities, such as faster 3D rendering times or real-time rendering engines,¹⁴ allowing one to preview three-dimensional scenes whilst they are being created. Because the rendering process has improved substantially, images can now be converted to higher resolutions, which subsequently pushes the display capabilities to larger scales. This production cycle facilitates the revolution of materiality.

In order to answer the question of whether a digital space experience can be regarded as valid, and whether it can generate pure emotion, further investigation is needed. The creation of such an experience is based on various media tools,

¹⁴ “Rendering” here refers to the process of generating and calculating 2D motion pictures from virtual 3D scenes.

which are declared by Manovich (2007) to be responsible for the vanishing of purity. The production process for a final 360° moving image involves various, complex media processes, in which 2D or 3D animations are created—or a mixture of both. Which of these forms can be regarded as purer: a 3D animated image space, or an original 2D image space, based on photography? As an example, the production, distortion, visual dimensions, and layers of the 360° moving image will be investigated.

3.9.2. Purity in 2D and 3D Animated Image Spaces

The process of creating a final moving image on a 360° canvas involves many distortions, transformations, and slicing processes before it can finally be observed—well-arranged as a whole 360° image—on the curved canvas of a dome. The final aim is to create the illusion of deep space, rather than an animated wall covering on the dome canvas. Of the two following examples, the first is prepared inside a 2D arranged space, and the second inside a 3D space:

1. Example 2D: “Der dreiäugige Totenkopf” (art director Beyer, 2018).
2. Example 3D: “Touching the Edge of the Universe,” Galileo Scene (Buczek, 2008).¹⁵

In the first example, the 2D moving image was originally prepared as a 2D panorama collage, and subsequently wrapped and animated in the computer

¹⁵ See <http://www.isabellabuczek.com/index.php?id=104&L=2>.

software Adobe After Effects [Computer software, screenshot, January 18th 2018]. Inside the huge panorama, the characters and all the elements of buildings and other things contained in the show were animated to move from the beginning to the end, guiding the viewer inside the 360° visual space. As described by Manovich (2007), here too every element has its own individual layer with a list of variables that can be adapted accordingly, from movement to scale to transparency. Second, once the animation was ready and all layers were converted into one, the moving image was wrapped and distorted into an allsky format—a 360° distorted image. Third, the whole animation was rendered as a sequence of 360° distorted images in Adobe After Effects CC (January 2017). In the fourth and final step, the image sequence was sliced into pieces according to the projector set-up—each image per projector—in order to be displayed separately piece by piece, and by each projector simultaneously, constituting a single 360° image space. For systems with one fish-eye projector, the process of slicing and separating the display is unnecessary.

Throughout the whole process, the image has been strongly influenced by various variables, distorted, sliced, and divided into pieces, so that—hopefully—the final pieces will result through the dome projection in one coherent 360° visual space. The first work example opens a coherent and highly aesthetic image space, although the depth of a three-dimensional space is missing in this 2D arrangement and production. Yet, because of the fog in the scene and a good usage of perspective, adding depth of field for each object, the average viewer would not notice that it is only a 2D animation. Spatial animation is not possible, and the audience cannot be moved via the camera inside the 360° visual space

and around the objects in the scene. The animated objects can only be moved around the viewer.

Conversely, in the production of a 3D animated image space, a 3D scene file has to be created from scratch inside a 3D software program, such as Autodesk 3ds Max [Computer software, March 2018], or a 3D game engine like Unity3D [Computer Software, May 2018]. Such a scene file contains three-dimensional objects, which are created by connecting vertices. When all vertices are connected, polygons can be arranged and the surface can be adapted. Once the creation of a scene file is completed, all objects that it consists of are strictly defined by one language. This definition contains geometry, viewpoint, texture, lighting and shading information for each surface in order to describe precisely the spatial arrangement of the virtual scene. The data contained in the scene file is then passed on to a rendering system in order to be processed and output to a digital image, which mirrors the virtual 3D space. The 3D scene can additionally contain a camera with specific settings. For the creation of 360° images, a fish-eye camera can be chosen to calculate an image sequence with a final distortion that matches the dome's inner surface. Similar to the 2D production, the image sequence then needs to be sliced and projected onto the inner surface of a dome environment. Only for systems with one fish-eye projector the slicing process can be omitted.

When comparing the production processes of 2D and 3D animated image spaces, it can be concluded that the 3D animated image is more suited to the IDE. For instance, in the 3D Galileo scene, the camera moves into Galileo's study room.

Through the three-dimensional arrangement, the audience is being relocated through the Galileo scene via the camera movement inside the dome environment. The audience can be immersed in the scene, objects can be seen from different angles, and a pure spatial experience can be created. The 3D space created through 3D software is thus more valuable inside the IDE, as the 2D production process—using distortion and only mimicking a 3D space inside the 360° cupola environment. The virtual 3D space can also be further enhanced via scanning processes, as will be explored in the proceeding subsection.

3.9.3. 2D Versus 3D Objects and Volumetric Scans

Archaeological objects that have been preserved for several thousand years possess a specific aura¹⁶ (Böhme, 2001) and authentic appearance. Therefore, they should not be copied—in the sense of rebuilding them through three-dimensional modelling by hand. In order to maintain the authenticity and aura of the object, it is crucial to use intensive, volumetric scanning processes and digitalise these objects pixel by pixel, and then pixel by voxel in order to produce an authentic volumetric model.¹⁷ These processes produce a visualisation that might be considered even more truthful than an analogue photograph—which reveals only a single, flat, specific, two-dimensional view and a single perspective chosen by

¹⁶ The term aura was first established by Walter Benjamin being described as unapproachable, authentic and unique. An aura could only be possessed by a work of art and not by objects which are reproducible. (Benjamin, 1979) The term was further elaborated by Gernot Böhme.

¹⁷ A voxel is a value in three-dimensional space. The term is derived from the terms “pixel” and “volume” (Kaufman, Cohen, & Yagel, 1993). Volume graphics are regarded as more advantageous than surface graphics, such as photography, since they are viewpoint-independent and therefore used preferably for simulated data sets (Kaufman et al., 1993).

the individual photographer—whereas a three-dimensional model allows viewers to make their own choice from multiple perspectives.

It is becoming more and more common to root storytelling in the same data that researchers use (Wyatt, 2002). Therefore, creators, designers, and artists not only have to keep abreast of new and emergent technologies that further enable such visualisation processes, but also preferably make the resulting visualisations available—both for experience and spatial discovery—to scientists, the public, and local communities alike. As argued in the previous chapter, practical work in academia, the arts, and technology should exchange with, and update, each other in order to ensure the best possible ways of visualising, modelling, and communicating their knowledge to the public.

Of course, these developments in academia and the arts modify both knowledge production and knowledge representation, as well as our knowledge context—thus, changing our perception. They teach us new ways of seeing, experiencing, and understanding, altering our perspective on the world around us, as well as our identification with it. In doing so, visualisation practices help us to expand our self-constitution—the relation of our body to nature, to the local, global, or cosmological space.

3.10. Passing by Flying Through Digital Space

Since in my research methodology, “the passage” represents both the key element and the golden thread running throughout the work, the realisation of the passage by flying through digital space plays a pivotal role. Therefore, it is to this

element that I now turn, highlighting its potential to generate emotive and lasting experiences of embodied knowledge, as well as the potential conflict between emotive design and scientific accuracy.

3.10.1. The Sound of Knowledge: Emotive Design Versus Scientific Accuracy

In the scientific visualisation of astronomical phenomena—or even more generally during the creation process—there is (and always will be) the conflict between scientific correctness and aesthetic—or artistic—expression. There are several recurrent difficulties, such as astronomical distance, which is always problematic for any scientific visualiser, or the size of the planets in relation to the sun and to each other in the solar system. Another problematic area is the topic of sound. Is there sound in outer space or not, and if so, how should it sound? This second issue is significant, not least because emptiness can also have an emotional sound. We might ask: should a passing asteroid have a sound effect in the IDE or not, and if so, how should it sound? Since, as designers of emotional experiences, we know how important sound is—especially immersive spatial sound—everything that can be observed in the dome would have at least an emotional sound.

Thirdly, there is always discussion about spatial flight—an important tool in astronomical visualisation—for example, flights from earth to another galaxy, or flights in-between celestial bodies. The chosen time frame of a given passage is crucial to the sense of how realistic it appears. When we use light-years as our chosen speed, there is already a certain constraint applied. How meaningful is it then to show spatial flights to far-flung destinations such as other galaxies, simply

by multiplying the realistic space flight time, so that it can be reached in seconds and visitors get somehow accelerated through time and space, determined only by an algorithm in a computer program? The destinations that can be reached at today's real space flight speed in the time frame of a human lifetime represent a time frame that humans can still imagine or relate to. However, what happens if this speed is extended to the speed of light, suggesting people are, or will be, able to fly at light speed, which is currently not the case (see also McConville, 2014)?

Distances thus need to be communicated very carefully, always accompanied by clarifying information and giving their relation to human space flight, to the human lifetime, and to the local human time frame. Furthermore, we cannot go to Mars and start a plantation "under a tent" today, as the film "The Martian" (Scott, 2015) implies. The exact opposite is the case—we need to start treating our home planet in a sustainable way if we are to be able to live here for the next 100 years without a gas mask. When executed correctly, visualisations in digital spaces can play a role in fuelling our sense of connection with, and responsibility towards, the planet.

3.10.2. Making Vast Distances Intelligible

In her PhD thesis, Donna Cox (2008) discusses the problem of visualising astronomical data across vast distances and explains how she tries to make them intelligible. Throughout her dissertation, Cox worked at the Advanced Visualization Laboratory (AVL) at the National Center for Supercomputing Applications. Cox and her team develop dynamic models and maps via numeric data, representing vast areas of space. For instance, I remember seeing dynamic

models at the International Planetarium Society Conferences (IPS)—the animation “Colliding Galaxies” and “Virtual Voyage from Milky Way to Virgo Cluster” in the show *Black Holes: The Other Side of Infinity* (Lucas, 2006), as well as a separate tornado animation. These “animated computational scientific visualizations,” Cox (2008, p. 1) terms *visaphors*—a combination of the terms visual and metaphor.

I remember that I found the tornado sequence especially impressive, not least because I never imagined that I could be *inside* a tornado myself. The model of the tornado included so much dust and debris—so many particles and detail—that the whole experience, combined with sound, appeared quite realistic under the dome. It caused an impressive emotional effect, also in the long term. Yet how can such a dynamic model be epistemic, enlightening, or in other words give access to knowledge and perspectives that could not otherwise be obtained? Whilst working with my students, very often I came to realise that it is not the final piece that speaks to them, but more the process of creation—revealing and making transparent all the visual techniques used to accomplish the final moving image. Therefore, regarding the tornado sequence, it was probably not the final polished sequence, but more the “making of” that was most appealing to me, showing all the different layers of debris and dust from which the tornado was built. This is similar to how an exploded visual study of a screw by Da Vince (see section 4.3.2.3 of Chapter 4) appealed to me.

3.10.3. Digital, Spatial Interpretations and Instrumental Realism

Yet how many parts of the model are realistic? Meaning, how many properties of the real-life natural phenomenon need to be adapted to virtual parameters in order to result in an authentic and realistic experience? If we take a galaxy collision for example—one of Cox’s beautifully named visaphors—even in the IDE, should we not ask if a galaxy collision would be observable in a human lifetime? What relation does a galaxy collision have to our human life and body? Are these animated models hopelessly lost in the abstraction of millions of years in comparison to our microscopic human life?

I am sure there is a relation between ourselves and such great events, and there are also ways of visualising these relations and passages—from our evolution and lifetimes, to astronomical events. Don Idhe (1991) calls such visualisations “instrumental realism,” suggesting that, to some degree, our visualisation instruments and capabilities exceed our human imagination. He refers to a paradigm shift in the 19th century from unmediated observational methods towards an extreme reliance on technology-mediated empirical methods for defining the real (Idhe, 1991). Yet Cox (2008) seems to undermine this in her further remarks: “Yet the source can only claim to be purely digital; it is not directly coupled to any natural phenomenon” (p. 134). Cox further states that these digital visualisations would develop their own epistemology in relation to computer science, since we could gain new research opportunities for understanding how we derive knowledge from this purely digital foundation. The motivation is to be found in “the promise of new intellectual discovery, that could be enabled by scientific visualization” (Cox, 2008, p.140).

These visualisations can be concrete, for instance, emerging patterns run and simulated through evolution of the complex dynamic models that Cox (2008) describes. She further states that the scales of the galaxies have been manipulated—perhaps up to four times larger—in order to reduce the vacuous space between them, but they did so in a way that preserves the relative distances (Cox, 2008). In my own productions, for example in “Superheroes of the Deep Sea” (Beyer, 2017), I decided to adopt a similar approach. Of course, all the animals in the sea cannot be observed at once (as some Hollywood movies might want us to believe). In fact, a submarine has to travel for hours in order to discover perhaps only a single animal of a species. Therefore, in my 360° movie, I reduced the vacuous spaces of the deep and accelerated the time of the dive—albeit whilst updating the distance of the descent reached in order to ensure orientation was maintained.

3.11. Conclusion: Digital Space

Through the digital coordinate space of the IDE—a space of passages and transitions—authenticity can be enriched through volumetric scanning, providing insights into a much more complex reality. In Heßler and Mersch’s (2009) words, the IDE can be used as “the instrument for analysis in the process of gaining knowledge” (p. 15). Yet, most importantly, the spatial arrangement of knowledge inside a digital space or spatial container is to be understood as a new “in-between” space (Mersch, 2006), giving a new spatial context for exploration and discovery. This possibly even leads to a change of perspective regarding—for

instance, national borders—or self-relocation by reflecting on one's own location on earth in relation to the surrounding context.

The IDE, with its new technology capabilities, inhabits all these different spaces—from the Georama to the DUA—and can even add interactive, simulating, and dynamic modes to these spaces, which allow for further experimentation, whereas the Georama itself could only offer a still topology of the earth's surface. Moreover, the IDE can offer passages, described in this chapter as flights inside these spaces. It can even be used as a vehicle in its own respect, allowing one to travel through space, as the case study of the lift-off experience at the wind farm illustrated. The IDE further allows for passages between different spaces—for instance from the inside of a digital, dynamic Georama to the external surface of the earth, or a continuous flight passage towards another planet or solar system. It is through these passage experiences that knowledge and spatial awareness can be experienced and trained.

4. Tools of Thought: Artistic and Scientific Visualisations

In Chapter 2, the passage concept was enriched through different disciplines, whilst Chapter 3 explored the importance of models as active and transformative knowledge instruments working across the arts and the sciences. In this chapter, the epistemological potential that exists between the visual and the momentum of the passage is reevaluated, lifting the passage concept to another level. It further addresses the status of the visual and its capabilities as a knowledge instrument, or tool of thought. The process of knowledge production is being analysed in the arts and the sciences, illustrating the precise intersection of these disciplines inside the generation of new knowledge—either in the lab, or an art atelier, or a mixture of both.

It is contentious which discipline produces the most “real” knowledge: the arts or the sciences. In the course of conducting my PhD project, I frequently experienced the tendency to reduce all visual expressions to one, solitary ontological state of representation as limiting—that is, the tendency to have a single state of being or function as a reference for something pre-existing. By now, it should be a well-established conception that visuals are essential in the generation of new knowledge (see also Chapter 3). Pattern recognition, for example, can only be deducted from the field of vision, and not from logic or theory (Heßler & Mersch, 2009, p. 15). Therefore, the process of visualisation is

fundamental to many scientific and non-scientific fields of research, as only visuals—rather than theory, text, or numerals—have the unique characteristic of visual immediacy. The denigration of the visual within the sciences to only its representational capability thus reaches the same irritating intensity as the argument that art is merely a decorative supplement, and that artistic expression only serves scientific illustration—or, in other words, it only serves to make scientific illustration more aesthetically pleasing in scientific practice, and especially in scientific outreach (Mersch, 2006). Should art not be regarded as equal to science in the generation of knowledge, or even be considered as helping the sciences in this process? Answers to these questions will be presented in this chapter.

Some research has already been conducted to raise the status of visuals to “tools for thought” (Dennett, 1996); “exograms” (Donald, 1991); “epistemic actions” (Kirsh & Maglio, 1994); “constructed visibleness” (Heßler, 2006); “heuristic instruments” (Bauer & Ernst, 2010); “metaphor” (Kuhn, 2012); “visaphor” (Cox, 2008); “transcalar imaginary” (McConville, 2014); or “thought-images” (Sloterdijk & Funcke, 2005). However, opinions on the value of visuals remain polarised, and today visuals continue to be seen as mere cognitive amplifiers (Malafouris & Renfrew, 2010).

Dr. Lambros Malafouris (2010), from the School of Archaeology at Oxford, and Lord Andrew Colin Renfrew (2010) of Caimsthorn, professor of archaeology in Cambridge propose “that [the] representational phenomena and properties [of visuals] are at best the shadows of what . . . we call ‘the cognitive life of things’” (p. 3). They believe

that visuals, and how we interact with them, have a much greater potential, explaining that the cognitive life of things emerges when images—both those within the mind and those without—start “spiking,” exchanging, and complementing each other; a process through which memory emerges (Malafouris & Renfrew, 2010) and thus the ability to learn and further our knowledge. These moments of transition, threshold, or fruitful blending, I refer to as the passage moment, following the Ariadne’s thread already established in this thesis and based around the concept of “Le Passage” (see Chapter 2). The configuration and reconfiguration processes that are so common in artistic and scientific practice can also be considered as passage moments, which occur when concepts, patterns, artefacts, things, and objects are put together, broken apart, or synthesised to form something new—a process that is similar to clay modelling, in which all meaning can be changed and reconfigured. It is also a process in which things can finally be put into different contexts, changing their initial state and meaning. Malafouris and Renfrew (2010) label this “a process that characterizes and allows for the passage and interaction between the states of thingness and objecthood” (p. 5). They base this concept on theories built around the extended and embodied mind (see Adams & Aizawa, 2001; Clark, 2008; Clark & Chalmers, 1998).

This chapter first proposes a new framework for the conception of visuals and their place in knowledge production by following both Malafouris and Renfrew’s (2010) work, and the passage concept central to this dissertation. Second, it is intended to clarify and present the real potential of art, both within the sciences and more generally, illustrating the ways in which both disciplines can produce

new knowledge—either separately, or even in collaboration—and mapping their potential meeting points. Exactly here—at the intersection of art and science, in these passage corridors—the most valuable visual instruments can be found. Third, this chapter offers itself as a source of inspiration for artists, designers, and creators, highlighting different artistic techniques and approaches, as well as providing tangible examples. This is a very important chapter, not least since this approach represents the starting point for my dissertation and I imagine will stay the subject of continuing interdisciplinary discussion throughout the coming decades.

4.1. Scientific and Artistic Distinctions

The first task is to define what the exact difference between artistic and scientific images is, and why there are so many misconceptions regarding the nature of visuals, their impact, and meaning. In one of the first presentations I gave in the course of my PhD programme—a research update entitled “The Scientific Construction of the Physical Reality in 360° Space or the Physical Real 360° Space of the Scientific Construction”—I concretised the difference following Gottfried Boehm’s (1995) conceptualisation. According to Boehm (1995), an artistic image has a richness of insinuation; it is metaphoric, autonomic, and self-referencing. In contrast, a scientific image is instrumental; it has an inherent purpose and an aim towards purity, and its main purpose is to reference something else. It tries to be as objective as possible, and has to be reproducible. Yet most of all, it is an image for consumption, which in an artistic sense is a deficit (Boehm, 1995). In my view, an artist creates an artwork that is

intended to be self-referential without having to be either pure or objective; the artwork can stand on its own. It is not prepared to be consumed in any prearranged way. It is free of any restrictions. Conversely, in scientific practice as well as scientific communication, the consumption aspect of scientific images is considered a strength. It has the ability to make the invisible visible, making scientific knowledge available to human cognitive faculties for a specific research community or scientific outreach project, and in doing so, the majority of people should be able to read it. Notably, there are also in-between visuals that have both artistic and scientific functions – as for example the 3D animation of the sky disc of Nebula out of a 3D volumetric scan (see chapter 5.2.5).

A further question is when and why an image is epistemic, and what the key categories of an epistemic image are. As Boehm (1995) points out, it is necessary to develop a set of criteria on how images (visuals) function, especially when the same image is being presented in different contexts—for example as an anatomical presentation, a sketch, or a painting. For example, in Boehm's work, an X-ray of the human brain and a drawing of the human brain by Leonardo da Vinci are presented, the first one exhibiting standardisation—a technological process of transparency—whereas the latter exhibits a strong cognitive quality. The X-ray is reproducible, whilst the drawing is not. Which of them contains more knowledge? Evidently—assuming that it is scientifically correct—Da Vinci's image contains more knowledge, connections, analogies, and synthesis. Visuals with fascinating epistemological potential give insights into things and processes that otherwise would not be available to us. In their capacity to reveal and therefore make something understandable through

visualisation, visuals possess one of the main qualities needed to form an instrument of knowledge.

4.2. When Visuals Act as Vital Instruments of Knowledge

Visuals can act as instruments of knowledge, either when drawn to meaningful concepts by artists—such as the drawings by Da Vinci—or as technology-driven images—such as X-ray or Magnetic Resonance Tomography (MRT) images, using, for instance, the different light waves of the spectrum. Visual technologies in diverse scientific areas—from the first optical telescopes to today's advanced microscopes and radio telescopes and satellites—are welcome tools that are able to enhance the possibilities of otherwise poor human cognitive faculties. We look through lenses, micro and macro glasses, photo geometric and volumetric scans, or animated film into a world beyond our senses, be it real or re-created. Sometimes we look through these human-made visualisation tools in search of new discoveries in order to widen our knowledge horizons, and sometimes we even utilise these visualisation techniques to save lives. In these time-critical moments, our lives depend on a few pixels and the particular brightness gradient of a Magnetic Resonance Image (MRI) or an X-ray (radiographic image). These pixels eventually decide if we are diagnosed with cancer, an undesired inflammation, or another disease, as well as what kind of therapy we will obtain. This absolute reliance on the visual capability of such an image and its pixels never ceases to amaze me, especially when compared with the absolute distrust of visualisation in scientific practice, and its inferior status as a mere decorative

supplement. Should visuals not rather be seen and accepted as an important knowledge instrument?

Besides technology-driven images and their crucial uses in the field of medicine, there are also other visual concepts that can be considered to enable an art of understanding—for example, visual analysis. These concepts have been accomplished through the use of forgotten visual methods developed by artists throughout history—methods such as specific ways of drawing and observing, capable of revealing knowledge that would otherwise remain unperceivable. This knowledge can involve geometrical, spatial, or structural understandings, which exceed the scale of the everyday. These visual methods may result in visual concepts that generate quite complex knowledge and therefore become more than mere cognitive amplifiers (Malafouris & Renfrew, 2010)—or, as Don Norman (2004b) would call them, “things that make us smart” (p.1). The science historian Thomas Kuhn (2012) described such models as metaphors, since they contain a sudden process of scientific discovery or even epiphanic realisation. This realisation causes a “gestalt switch” (Kuhn, 2012), resulting in a new mental image that offers sudden insights into a new order of phenomena. An example of this epiphanic realisation through drawing is provided in a visual study of Ramón y Cajal, here presented in subsection 4.3.3.

The various ways in which knowledge concepts such as the different cartographies employed by Cajal have been visualised determines how our understanding can unfold whilst we follow them. They offer several (passage)ways via which we can think and gain a deeper understanding. The

remainder of this chapter is devoted to the analysis of these passageways via the concepts of the “art of understanding”; “structural intuition”(Kemp, 2000); “concepts of diagrammatic” (Bauer & Ernst, 2010); and “visual explanations” (Tufte, 1997).

4.3. The Art of Understanding: A Meeting Point for Science and Art

“After all, artists and scientists have a common goal, which is to make the invisible world, visible. That is, to give us a glimpse of a world beyond our senses.” – Arthur I. Miller (2014, p.1)

Following Arthur I. Miller’s statement, I would like to illuminate how scientists and artists could potentially collaborate in order to make knowledge patterns tangible. I will look at how renowned scientists and artists such as Leonardo Da Vinci, Albrecht Dürer, Ernst Haeckel, and Irving Geis found common ground and learned the concept of the “art of understanding” (Kemp, 1992, 2000, 2004b) through visualisation—a concept that depicts natural phenomena and represents them in a very structured, visual way, whilst inhabiting an extraordinary spatial imagination. These visualisations can be considered knowledge instruments or metaphors that help us to experience, understand, and therefore gain knowledge of the things around us—whether they are close, far away, or otherwise invisible to us.

4.3.1. The Art of Understanding: A Definition

The art historian Martin Kemp (1992) coined the concept of “the art of understanding” to describe the specific drawing techniques deployed by Da Vinci and Dürer. He points out:

“They [Da Vinci and Dürer] are neither artists nor scientists, in that our pedestrian terminology simply fails to capture what they did in blending the deepest intellectual insight into the operations of nature with the highest imaginative acts of re-making.” (Kemp, 2004a, p. 6).

Each of them had their specific and intuitive understanding of the operations of nature, as well as their own methods by which to visualise them. The depiction of nature on paper has to be very accurate if it is to provide a foundation for further study.

I suggest that, although both artists orientated themselves on the Italian Renaissance and the laws of proportion in nature, Da Vinci’s and Dürer’s visualisation techniques were quite different from each other. Da Vinci’s animal drawings tried to discover invisible patterns of movement, or shapes of their inner constitution of muscles or bones, whilst Dürer’s drawings represent his in-depth observation of the superficial appearance of animals. When studying the paintings of both artists, it seems they use the gaze of the animals directed towards the viewers in some paintings as a medium to connect the viewer with the narrative of the painting, as well as to arouse an emotional reaction. In this

sense a passageway is created for the viewer to enter the encounter with the animal. The gaze thus becomes the connection or trigger point between the viewer and the art experience. Following the idea of the visual as an encounter rather than a static representation, the British artist Roy Ascott cited in Din and Wu (2015) stated: “Stop thinking about art works as objects and start thinking about them as triggers for experiences” (p.57). Following Ascott’s statement, each artwork needs to embody at least one trigger point in order to become a passageway towards a full experience—one that will hopefully have a lasting effect and enter our long-term memory.

Both Da Vinci and Dürer observed and studied objects, developed specific visualisation techniques, and—as a result—created drawing studies. These practices can be described via the concept of “the art of understanding.” But what criteria must visualisations meet in order to be qualified as an art of understanding? Martin Kemp (2004b) presents the following criteria: The art of understanding has to blend the deepest intellectual insights with the capability to recreate. The object needs to be understood from the inside as well as from the outside; a depiction of what can be observed on the outside alone is not sufficient. Once the constitution of a chosen object has been comprehended in all its depth, it needs to be re-made. Through the process of remaking the object—for instance as a drawing study—the knowledge gained through observation is now tested and enriched in the remaking process. As Kemp states only if these two abilities—that is, intellectual insight and remaking—blend together in the making of a valuable drawing that contains all of the knowledge acquired during

these two stages can someone else learn from it. Furthermore, this assumption is based on the observer's capability to read the drawing language (Kemp, 2004b).

I learnt these visualisation techniques during a drawing course conducted over a period of six months in preparation of a drawing portfolio in order to apply to the Muthesius University of Fine Arts and Design in Kiel, Germany, in the year 2000. My application was successful, and I began studying communication design in 2001. Below is one of the drawings I prepared at the time (Figure 4.1). It is an analysis of the constitution of a tomato from both the inside and the outside. Its symmetrical inner structure is presented through a diagram in the upper right-hand corner, illustrating its geometrical breakdown. The diagram is accompanied by a cross-sectional view of the same section, but this time in full colour and presented in the centre of the sheet. Whilst in the upper left-hand corner, a study of the stalk and its connection surrounded by leaves is presented, including the shadow falling on the round shape of the tomato's body.



Figure 4.1. Study of a Tomato . Drawing by Isabella Beyer, 2000.

In this study, I tried to show the different geometrical shapes that together constitute a tomato—the constitution; the different physical phenomena, such as light and shadows; and the material consistency of the tomato, all of which influence the illustration's appearance as a structured demonstration and breakdown, rather than a simple or direct copy. In this case, a simple replica of the object is not enough. If the artist does not also envision the inner volume, the drawn object can appear flat, devoid of internal structure.

4.3.2. Da Vinci's Methodology and Visual Tools

After studying Da Vinci's drawings and, even more importantly, his sketches, one can conclude that he had a specific methodology of configuration and re-configuration, which can be broken down into various visual and creative methods, which will be analysed and presented below with the aim of reworking them into new contemporary concepts and visualisations. My aim is specifically

to make these methods clear and tempting, ready to be reused by other creators—both of the visual and of knowledge.

4.3.2.1. Microcosm: The World in Miniature

Da Vinci tried to understand and see complex systems as a whole—no matter how small or large they were—and then to find analogies or, in other words, connections between them. I suggest in this approach, he was actually quite modern, trying to find fluent relations and commonalities rather than separating every entity, or search for rigid, artificial boundaries. This resembles the framework proposed by Malafouris (2013) with “permeable soft interfaces and semipermeable membranes” between things (p. 179). In doing so, Da Vinci followed the broader philosophical framework of the microcosms.

In Greek “*mikrós*” means “small,” whilst the word “cosmos” refers to being part of the whole (cf. macrocosms). In the cosmological orientated anthropologies and the philosophy of nature during the Renaissance, the analogy of the human being and the world was of particular importance. Therefore, it is no wonder that Leonardo da Vinci was also thinking within this framework. Both the terms “microcosm” and “macrocosm” are based on the imagination of a sublime world order. This order postulates that there is an analogous relation between the world and its parts, especially the human being. The cognition of one part of the world enables congruity with the cognition of the whole, and each imagination of the whole has its equivalent in its parts. The macrocosm is presented as a conscious and living unity; the microcosm as a mirror or reflection of reason

(*logos*) (Geo Themenlexikon Philosophie, 2007). This view helped the Pythagoreans to form their theory of harmony and numbers—despite the assertion of the modern sciences today that no harmonic analogy between micro and macro has been found (Geo Themenlexikon Philosophie, 2007).

Da Vinci created his visual concept of a microcosm around each object of his investigation. For example, to him the human body was an autonomic living organism on its own, constituting a whole world in its own right: “The body of the human being as a microcosm or “lesser world” is vivified by the pulsing of the blood in its vessels just as the “body of the earth” is given life by the waters that ebb and flow across and within it” (Da Vinci law 4 as cited in Kemp, 2000, p. 13). Via this approach, Da Vinci developed a holistic understanding of nature, which can be regarded as one of his methodologies.

The microcosm method can be found in models that are created as autonomic entities, such as ancient globes, armillary spheres, or living nano-organisms. Microcosmic models aid the user in their ability to imagine “worlds” that are different in scale, and where different rules apply—worlds that are different and invite one to “play around” with new ideas (Dissanayake, 1995, p. 96; McConville, 2014), or to apply and compare their mechanisms to the human scale. Of course, this function also touches upon the research field of nano-engineering.

Geometrical Bodies

Through his continuous exploration of nature and the open questions those explorations posed—which he tried to, and indeed did, resolve in his sketches—

Da Vinci developed several visualisation techniques, such as geometric bodies, exploded diagrams, analogies, analysis and synthesis, cross-section view, and segmentation and organisation by proportion.



Figure 4.2. Woodcut showing the dodecahedron as a solid form, by Leonardo da Vinci. In *De Divina Proportione* (pl. XXVII), by Luca Pacioli, 1509, Venice. Canadian Centre for Architecture, Montréal, Call no. CAGE W10310.

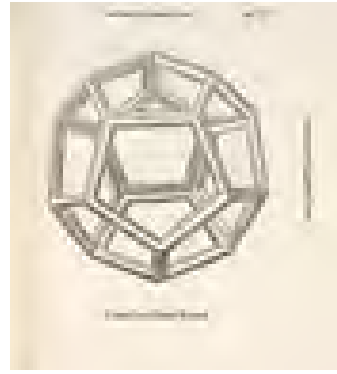


Figure 4.3. Woodcut showing the dodecahedron as an open frame, by Leonardo da Vinci. In *De Divina Proportione* (pl. XXVII), by Luca Pacioli, 1509, Venice. Canadian Centre for Architecture, Montréal, Call no. CAGE W10310.

Da Vinci had an exceptional talent for spatial visualisation and imagination. For example, he produced perfectly calculated architecture drawings for Luca Pacioli, using shapes such as dodecahedrons (Figure 4.2). His method of using geometrical bodies, both solid and in skeletal form, enabled Da Vinci to develop an extraordinary spatial visualisation. This way he could manipulate geometrical sculptures in his mind, and apply them to paper.

4.3.2.2. Exploded Diagram

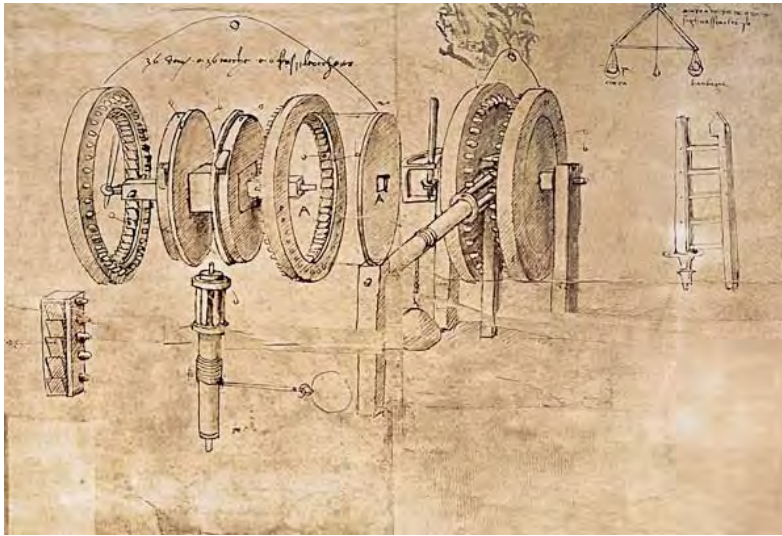


Figure 4.4. Three-dimensional exploded diagram (perspective). Drawing by Leonardo da Vinci. 1503 Original in Codex Atlanticus ¹

Da Vinci used three-dimensional exploded diagrams to describe, for example, gearwheels (Figure 4.3). That way, many of his imagined machines could be represented and rebuilt in later centuries. This technique has been adapted by, for instance, engineers before a machine is rebuilt. The diagram technique itself is still used today in order to explain and reveal the inner structure of objects.

¹ Retrieved from <http://www.codex-madrid.rwth-aachen.de/essays/freilauf/rahmen.html>, see also: <https://www.leonardoda-vinci.org/>

4.3.2.3. Analogies, Analysis, and Synthesis



Figure 4.5. Analysis and synthesis: The foetus in the womb. Verso: Notes on reproduction, with sketches of a foetus in utero. Pen and ink over red chalk. Drawing by Leonardo da Vinci. c.1511 © The Royal Collection Trust²

In this drawing of a mother's womb containing a baby presented in Figure 4.5, one can see how Da Vinci tried to make sense of the baby's development whilst comparing it to other natural phenomena such as plants, taking examples from nature that he could observe. Here, he tried to build on analogies, analysing similar concepts and putting them together to create something new. In this particular image, he imagined the mother's womb as a shell with a specific, zip-like structure (visualised in the right-hand corner of the image). During the time the image was drawn, there was virtually no knowledge about the inner organs, and medicine was extremely rudimentary. It was also forbidden by the church to

² Retrieved from: <https://www.royalcollection.org.uk/collection/919102/recto-the-foetus-in-the-womb-verso-notes-on-reproduction-with-sketches-of-a-foetus>

dissect human bodies, as the creation of humans was regarded to be God's work only. Therefore, Da Vinci's studies were difficult to continue. Nevertheless 1517 he has conducted above 30 but only when becoming a public figure he had the access to corpses, which were mostly bodies of executed criminals (Sooke, 2013).



Figure 4.6. Hair and water studies, by Leonardo da Vinci. ca 1504–06 from Kemp, 2004a, p.5-6

Da Vinci continually investigated the structures of natural phenomena—both the static and the dynamic. Before drawing water, he compared its movement with hair in order to find analogies (Figure 4.6). He found a visual analogy in the motion of the surface of water, and the flowing movements of human hair. Through the process of deduction—also referred to as analysis—he broke the larger concept of water down into simpler ideas in order to gain a better understanding of the phenomenon in its entirety. That way he discovered two

motions: one dependant on the weight of the strands, and the second on the manner of its revolving (Kemp, 2000).

Proceeding, Da Vinci continued to synthesise. Synthesis is a higher process that creates something new. It is usually done towards the end of a study or scientific inquiry. Two or more concepts are compared, shared, and put together in order to create something new. As a synthesis, Da Vinci developed the vortices as presented in the image to the right in Figure 4.6. Further, I observed Da Vinci separated detailed views of water into different case studies. Some studies included the visualisation of an obstacle in the water, forcing the water to interact with it.

4.3.2.4. Cross-Section View



Figure 4.7. Cross-section view of a human skull. The skull sectioned. Verso: The cranium. Pen and ink over black chalk, drawing by Leonardo Da Vinci. 1489. © The Royal Collection Trust.³

Another technique Da Vinci used was the cross-section view. As seen in Figure 4.7, the skull is empty, and one can only see the bone structures. Specific elements, such as the teeth, can be observed from the view within, looking through the mouth. The proportions are defined by thin lines, and the inner construction can be perfectly observed.

³ Retrieved from: <https://www.royalcollection.org.uk/collection/search#/9/collection/919057/recto-the-skull-sectioned-verso-the-cranium>

4.3.2.5. Partition by Proportion

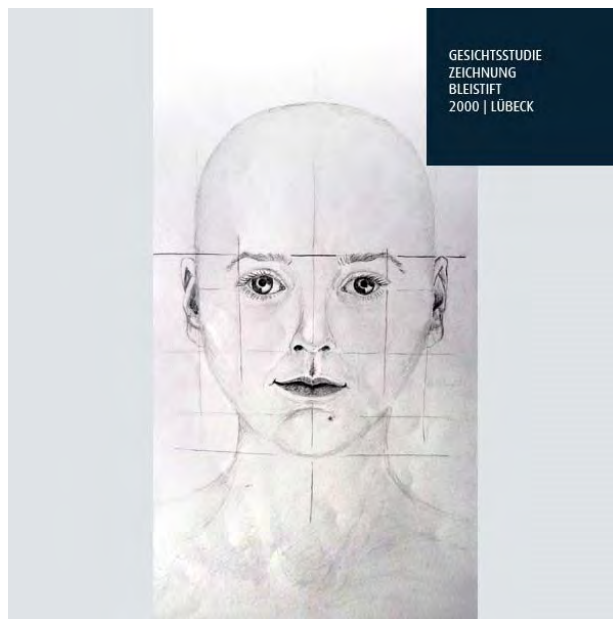


Figure 4.8. Facial proportions, drawing by Isabella Beyer, 2000.

Da Vinci's visualisation techniques remind me of my own drawings. Only by drawing I realised how different the human proportions really were from the common imagination. Most people I asked, stated that they imagined that, at most, the upper portion would be only one third of the head. The lower part of the face up to the eyebrows is around 15 %, whereas the area from the eyebrows up to the very tip of the upper head makes up another full 15 %. This can be nicely observed in Da Vinci's sketch (Figure 4.7), as well as in my own (Figure 4.8).

4.3.3. The Cartography of the Brain: Knowledge Evolution

No other part of the human body has aroused so much interest, imagination, mystification, and serious research as the brain. One reason might be the natural human need to understand oneself, specifically how we see, recognise, and make sense—both of our environment and ourselves. In order to gain more

knowledge about the functionality of our brain, much research has been conducted over the centuries, accompanied—of course—by visualisations. From cartographies of the different parts of the brain, hand-drawn to differing scales, to contemporary technology-driven visualisations such as MRT—which are used in the medical environment on a daily basis—visualisations have developed many insights into this organ. This subsection briefly illustrates how the understanding of the human brain developed through visualisation over the centuries—albeit without seeking completeness. Several examples will be given to sketch the evolution of this knowledge. Several examples will be given to sketch the evolution of this knowledge, demonstrating how visualisation techniques such as those described in section 4.3.2 can function as active tools of thought.

Most importantly, and in order to ground our journey in the art of understanding, we need to appreciate that the first imagination of the brain was accomplished by drawing—from the first rudimentary fantasy drawings, showing different images of the inner head, to slightly more precise and realistic drawings by Cecile Vogt—a French neurologist born in the final decades of the 19th century. Vogt's drawings localised the areas of the brain through low intensity electrical stimulation experiments (Figure 4.9).

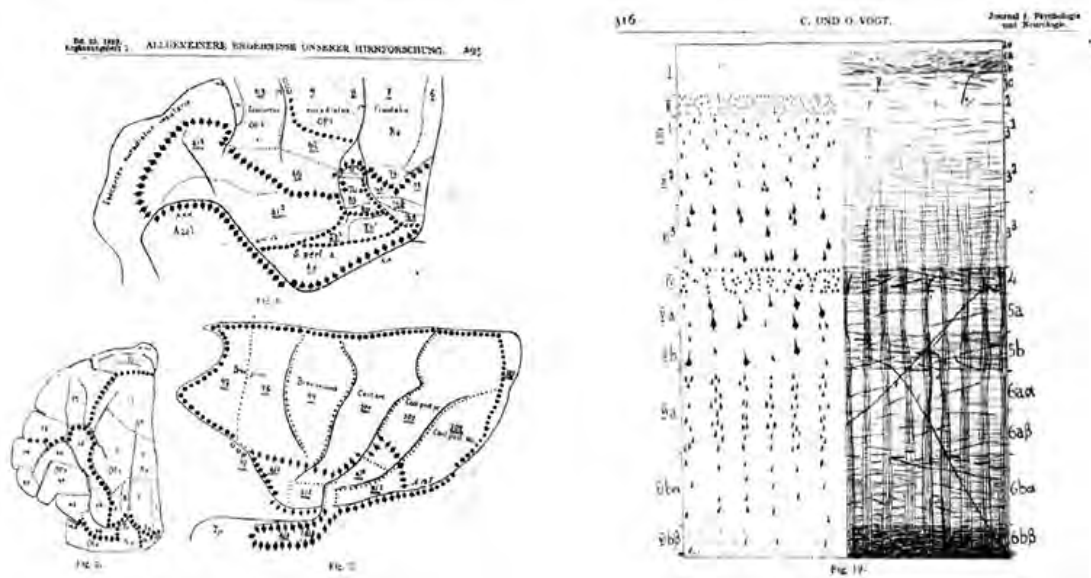


Figure 4.9. Examples of brain region mapping (left) and cortical myeloarchitecture (right). Drawings by Cecile Vogt. In "Allgemeinere Ergebnisse unserer Hirnforschung," by C. Vogt & O. Vogt, 1919, *Journal für Psychologie und Neurologie*, 25, pp. 277–461. XI .4

Vogt's work preceded the drawings of the German neurologist Korbinian Brodmann, who—through his observations and experiments on brains—could already distinguish between the different cell configurations and brain areas (Figure 4.10).

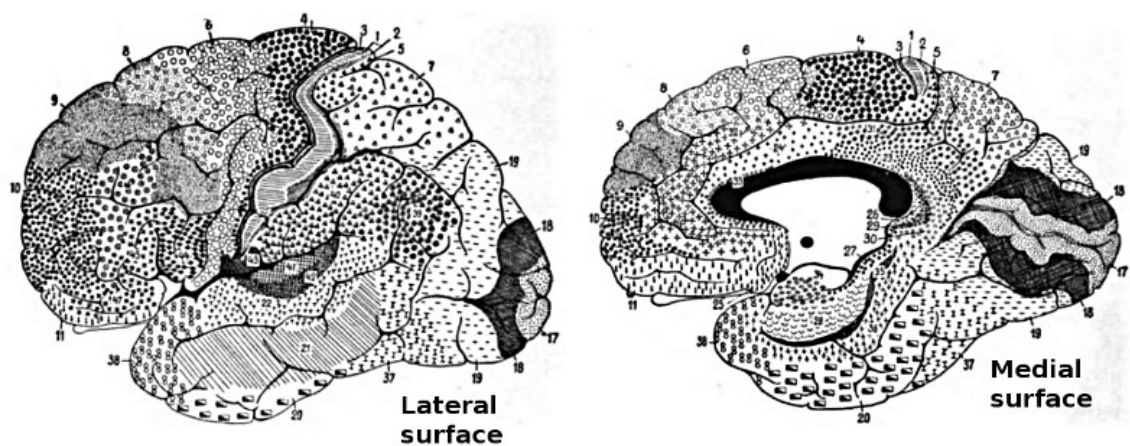


Figure 4.10. Brodmann's diagram of the cerebral cortex with the areas he identified. Drawing by Korbinian Brodmann, 1909, Brodmann-Museum, Hohenfels, Germany.⁵

⁴ Retrieved June 24, 2017, from <http://wineurope.eu/vogt-2/>.

⁵ Retrieved June 21 2018, from <http://www.korbinian-brodmann.de/gehirnschnitte>.

These were subsequently followed by the drawings of the Spanish physician Santiago Ramón y Cajal (Figure 4.11).

In 1885, Cajal became aware of the Italian doctor Camillo Golgi's invention; a dyestuff made out of silver salts that allowed the cells and cell junctions to be visible to the human eye under the microscope. In 1890, Cajal succeeded in tracing the cells in the brain and inside the spinal cord by using this process (Robin, 1992, 44). Through his drawings, he was able to prove that the nerve endings were separate, anatomically disconnected entities. He then concluded that the connections to the nerve endings have to be established anew each time the nerve activates. For this discovery Cajal and Golgi were awarded, and shared the 1906 Nobel Prize for Medicine and Physiology.⁶



Figure 4.11. Drawings by Santiago Ramón y Cajal, n.d. In *The Beautiful Brain: The Drawing of Santiago Ramon Y Cajal*, by Larry Swanson, Eric Newman, Alfonso Araque, and Janet Dubinsky, 2017, New York: Abrams Books.

⁶ Retrieved from: <https://www.nobelprize.org/prizes/medicine/1906/summary/>

On the day the Prize was awarded, Cajal took his drawings with him in order to convince the scientific community of his discovery, and showed them on slides at the scientific meeting in Germany in 1889. Janet Dubinsky, a neuroscientist from the University of Minnesota, describes the event as follows:

He sets up a microscope and slide, and pulls over to the big scientists of those days, and said, "Look here, look what I can see. . . . Now do you believe that what I'm saying about neurons being individual cells is true?" (Dubinsky as cited in Klein, 2017, para. 14)

Once more, the topology of Cajal's drawings—the visual—as such enabled the discovery of new phenomena. Validity was achieved, not through argumentation, but through visual evidence—*evidentia*. Cajal could not have gained this knowledge if he had not visualised his observations step by step, subsequently comparing, analysing, and synthesising them until he reached a new order of things.

Comparing Ramón y Cajal's drawings of the brain with contemporary technology-driven images, such as magnetic resonance imaging (MRT), Cajal's drawings add a particularly important dimension to the development of neuroimaging, and substantially furthered our understanding of the brain. His drawings not only present a final image, but also make visible the process of configuration and reconfiguration through which Cajal reached his final conclusions. Whereas contemporary MRT are insightful, they nevertheless remain limited for the simple reason that they are detached from the passage of

time and all its linkage effects and synergies. MRT recordings are simply segmented slices that stand in isolation from their surroundings. In this snapshot, the interplay between the presented brain area and other areas of the central nervous system is missing (Bauer & Ernst, 2010, p.261). The dynamic process of human perception cannot be explained by a single such snapshot. In this sense a MRT or similar technology-driven image provides only a momentary insight into the complex proceedings of our brain.

4.3.4. The Microscopic World: Making the Invisible Visible

The first pioneers, such Robert Hooke and Ernst Haeckel, discovered the microscopic realm through drawings, opening a window into worlds far beyond our unaided senses. As Hooke (1667) remarked, “the limits, to which our thoughts are confined, are small in respect of the vast extent of Nature itself; some parts of it are too large to be comprehended, and some too little to be perceived” (preface).

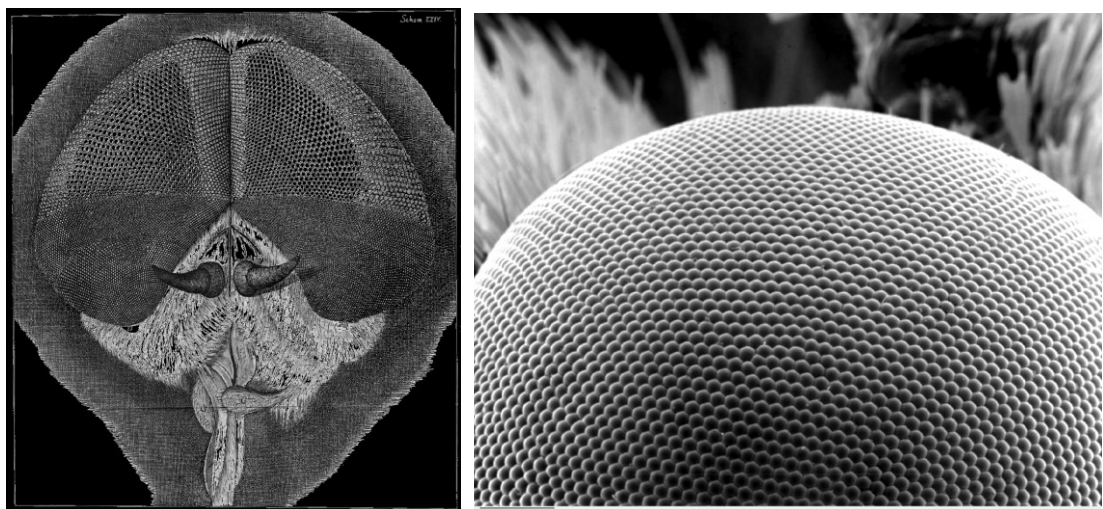


Figure 4.12. *a* [left-hand side]: The eyes of a grey drone-fly. Drawing by Robert Hooke, [1667]. In *Micrographia* [Schema 24], by Robert Hooke, London: Jo. Martyn and Ja. Allestry,

Figure 4.13. Scanning electron microscope image of the eye of a noctuid moth (right). Luisa Howard (date n.n.)⁷

Hooke was delighted to discover how the grey drone-fly might perceive its world as well as the structure of its eye, its structural organisation, and behaviour, which he referred to as “hemispheres” (Hooke, 1667; see Figure 4.12). This polyhedral array was as fascinating as any other realm of natural engineering. Hooke (1667) discovered that “[a] fly may be truly said to have an eye every way, and to be really circumspect,” and is even “able to see backwards also over his back” (p.1).

Hooke, Haekel, and many other microscopists started to discover the micro-engineering present in nature and developed questions regarding its principles, how these structures develop, and whether there is such a thing as “natural engineering” that explains analogous configurations in animate and non-animate objects in the context of physico-chemical laws (Kemp, 2000). Or, in modern terms, are there common principles of spontaneous self-organisation at work across the inorganic and organic worlds (Kemp, 2000)?

⁷ Retrieved from <http://remf.dartmouth.edu/images/insectPart3SEM/source/8.html>

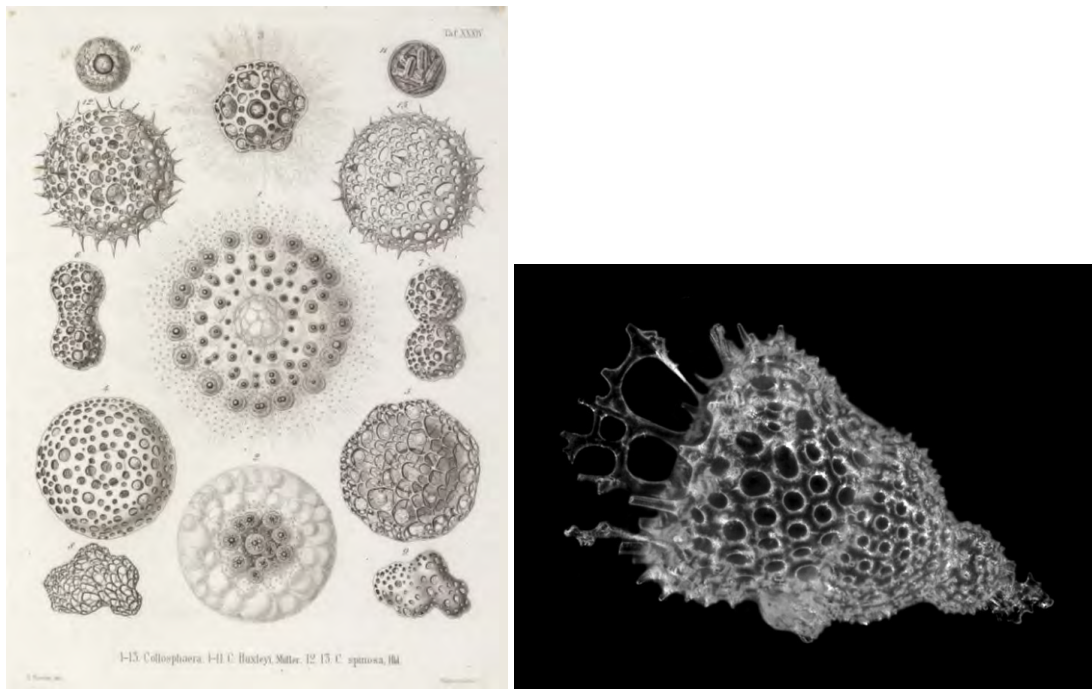


Figure 4.14. *[left-hand side]*. Structures of natural forms. Various classes of radiolaria. Drawing by Ernst Haeckel, (1862) © The Royal Collection Trust.

Figure 4.15. *[right-hand side]*. Photomicrograph of radiolaria. Photograph by Frank Fox, 2015.⁸

Both artists Hooke and Haeckel used an art of understanding and committed to paper what they saw and imagined. Their work represents the first steps in making the invisible world of microscopy visible to us—a world that still continues to amaze and astound us today. How accurate Haeckel's drawings were can be compared with the photomicrograph figure 4.15.

Haeckel in particular inspired many later architects and engineers. One famous example here is the architect Antonio Gaudí, who tried to use some of the forms Haeckel drew of nature in his Sagrada Família in Barcelona (Kemp, 2004a).

⁸ Retrieved from <http://www.mikro-foto.de/radiolarien-aus-barbados-2.html>

Today, there remains so much to learn from nature, especially from very small structures that tend to be very stable due to their small size. In the search for more resistant materials, research on nano-structures and nano-engineering continues.

4.3.5. Resuming the Art of Understanding

As became evident, the art of understanding is also a search for structural organisation and pattern recognition, finding analogies and, consequently, new solutions to scientific questions. Therefore, in order to be classified as epistemic or as an art of understanding, drawings need to exhibit what Kemp (2000) labelled “structural intuition.” They need to be “constructed images, in which it is impossible to separate observation and representation from analysis and synthesis,” as Kemp (2000, p. 4) explained in relation to Da Vinci’s and Dürer’s paintings in his article “Structural Intuitions in Art, Architecture, and Science.” The object is thus observed, and subsequently represented by drawing on paper. This creation process is not distinguishable from analysis and synthesis:

Analysis > a bigger concept is broken down into simpler ideas

Synthesis > two or more concepts are being compared, shared, or put together in order to create something new

Thus, before a drawing is finalised, a broader concept is broken down into simpler constituent ideas or components. This happens during the analytical stage. Thereafter, synthesis can occur, constituting a much higher process in

which two or more concepts are compared and subsequently combined to form something new. This new concept can be a small, yet very important detail, a pattern, or a structure that repeats itself in different objects or elements, but it could also be a new meta-concept. Most importantly, it is a process of wonder and reassessment that is also part of scientific practice.

I am convinced that when the concept of the art of understanding with its many tools and methods is combined with new visualisation capabilities—such as flights inside the IDE through microscopic areas in real-time, embedded in their specific spatial context—this can add to the acquisition of knowledge and enhance the epistemic value of the experience. Additionally, it can add to our personal experiences of spatial insights into our local environment, giving a felt relation to our own perceived spatial scale, in which we operate on a day-to-day basis, if the passage between us and the visual succeeds.

4.4. The Diagrammatic and the Eye of Mind and Body

The diagrammatic is another important visualisation method, the key to which lies also in the passage experience, this time by following the line—that is, the graphical content of the diagram. In the graph, it is the interplay between dot, line, and plane that form the basis of the medium (Bender & Marrinan, 2010; Krämer, 2012).

The line of a diagram can evolve into Ariadne's thread. Following Leibnitz (as explained by Krämer, 2012), Ariadne's thread leads the dark and blurry cognition

in the labyrinth of our turbid consciousness towards a state of clarity. Through that act of leading, a process of exchange between the mental and the material occurs (Krämer, 2012). Therefore, the diagram creates new knowledge by acting as a mediating authority between thinking and intuition (Bauer & Ernst, 2010).⁹ It is in this interplay between configuration and reconfiguration—whilst our perspective is shifting—that the passage occurs, and enlightenment spreads until it forms a deep awareness and enters our long-term memory.

4.4.1. Defining the Diagram

In order to clarify what a diagram actually is, I would like to take a step back and focus on the key aspects of its definition. A diagram is a simplified drawing, showing the appearance, structure, or workings of something—a schematic representation, as stated by the Oxford Dictionary of English, further explaining that the diagram in geometry is a figure composed of lines that is meant to illustrate a definition, or to aid in its proof. Thus, in this definition the diagram is at least recognised as an important instrument of proof. Its origin goes back to the 17th century, stemming from the Greek *diagrammhai*, which means “marked out by lines”—*dia* meaning “through,” and *graphein* “to write” (Oxford Dictionary of English, 2010). The verb “to write” introduces the important component of “by hand.”

⁹ In German: *Anschauung*.

4.4.2. The Eye of the Mind and the Eye of the Body

In the essay “The ‘Eye of the Mind’ and ‘the Eye of the Body’: Decartes and Leibnitz on Truth”, Sybille Krämer (2012) a philosophy professor tries to correct the philosophical notion that the intellectual eye is only able to see clearly when the bodily eye remains blind. She supports her work by evoking epistemologies by Decartes and Leibnitz. Krämer refers to ocular seeing as tied to the illusionary, whilst valuing tactile seeing, which she conceptualises, not as an act of seeing with the mind, but a seeing with the hand. She explains that modern algebraisation stands for “diagrammatic” reasoning, its basis being the formation of an “operative” and “tactile” type of visuality (Krämer 2012). An example is the active process of configuring and reconfiguring algebra equations on paper or blackboard. Krämer (2012) further explains that “[t]he heart of science is not simply ‘abstractions,’ but the embodiment of objects of knowledge, the sensualization of abstractions and the visualization of the invisible” (p.380)—meaning the visualisation of a hidden logic. I would like to free ocular seeing from its seemingly negative connection with the illusionary, and focus instead on the fruitful symbiosis between the “eye of the mind” and “the eye of the body.” This approach supports the art of understanding as conceptualised by Kemp and explored in the previous subsection, combining many different views through analysis and synthesis.

Alfred Korzybski (1948) an engineer and philosopher adds to a definition of the diagram by referring to a map as a diagram: “The map is not the territory it represents, but, if correct, it has a similar structure to the territory which

accounts for its usefulness” (p.58). Therefore, the diagram is not supposed to be a realistic and detailed depiction, but is rather bound to a specific purpose—in this case, the drawing of a schematic map that would enable the reader to find his or her way around a city or specific territory. What is striking is how, in diagrammatic reasoning, the represented visual artefact needs to disclose only a basic idea—a basic structure that might be the foundation of everything else. Charles Sanders Peirce (1903), the founding father of the diagrammatic, argues that the diagram “should be carried out upon a perfectly consistent system of representation, founded upon a simple and easily intelligible basic idea” (p. 418). It is this basic, intelligent, fundamental idea that the diagram consists of, and that makes it both precise and valuable—such as, for example, the thin line of a planetary orbit, illustrating exactly the elliptical movement of a planet around the sun in our solar system.

4.4.3. The Diagram and Spatial Components

Krämer (2012) further states that, in order to be able to analyse the diagrammatic approach in the context of evidence and epistemology, the use of spatial relations needs to be considered, as predominantly non-spatial issues are being presented in a spatial, topological manner—top/bottom, right/left, central/peripheral—in order to introduce new, meaningful connections. Moreover, the elementary matrix of order established by our body-in-space is translated into a two-dimensional plane. This technique is enabled through graphism—an interplay between line, point, and surface—the heart of the diagrammatic, which presents cognition through the line (Krämer, 2012).

Charles Joseph Minard's diagram "Carte figurative des pertes successives en homme de l'Armée Française dans la campagne de Russie 1812–1813" [The French War March to Russia 1812–1813] (1869), for example, represents a three-dimensional spatial application on a two-dimensional plane, and helps to establish relations and make visible proportions that would otherwise not be seen (Figure 4.16). Matthias Bauer and Christoph Ernst (2010) suggest that this diagram includes a space of action and temporal progression in a cartographical composition. With these attributes, the image can also be considered constitutive of a narrative (Bauer & Ernst, 2010).

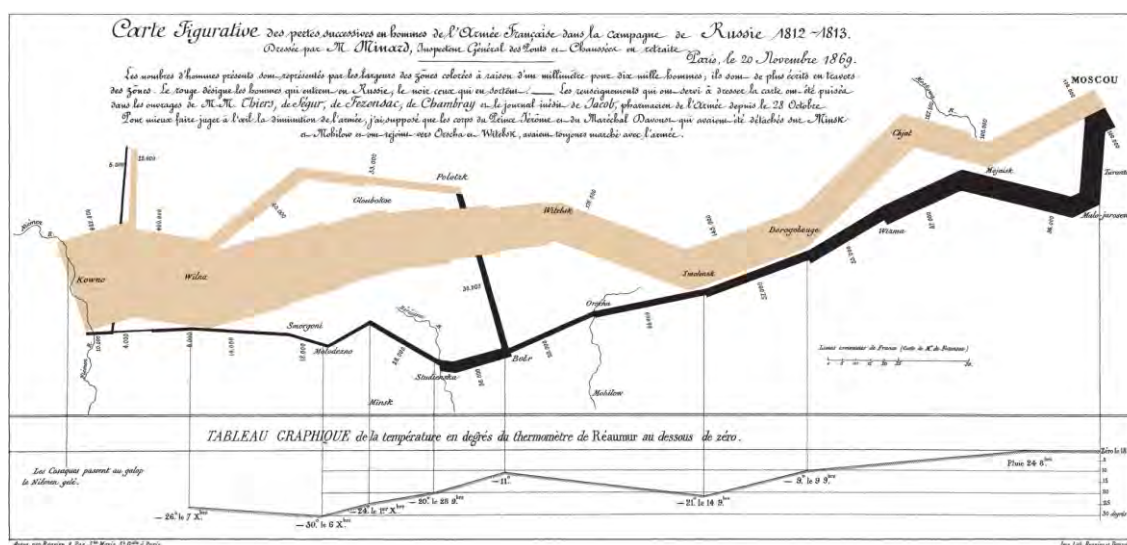


Figure 4.16. The French war march to Russia 1812–1813. Diagram by Charles Joseph Minard, 1869. In “Tableaux graphiques et cartes figuratives,” Bibliothèque numérique patrimoniale des ponts et chaussées. © École nationale des ponts et chaussées.¹⁰

¹⁰ Retrieved August 21, 2018, from

Minard's diagram illustrates quite adequately Napoleon's troops advancing towards Russia, and on their withdrawal back to France. Additionally, Minard also considered temperature differences and obstacles, such as rivers. The core statement of his diagram can be read through numerals, letters, and proportions. Relations that would otherwise not be perceivable are being made visible and re-enacted. Bauer and Ernst (2010) further state that Minard's diagram is a hybrid illustration, simultaneously preserving and fixing this moment in time.

The concept of diagrammatic reasoning can be further expanded to multifaceted practices, from an exploded drawing of the normally concealed inside of a wheel lock by Leonardo da Vinci (subsection 4.3.2.3) to maps of the brain (subsection 4.3.3), as Bauer and Ernst (2010) illustrate in their book *Diagrammatik*.

4.4.4. Resuming the Diagrammatic

In the context of this subsection, it is sufficient to state that both the art of understanding and the diagrammatic have a structural order. The diagrammatic tries even more vigorously to reveal the hidden organising structures of the objects and phenomena around us. Its processes are mainly those of reduction and clarification. The diagrammatic abstains from showing the object as it would normally be perceived by our senses. By excluding its outer body and surface, it instead reveals directly the basic structure and underlying logic. The concept of the diagrammatic can be combined with the immersive experience in the IDE for instance flights through space can be enriched through three-dimensional

diagrams of planet orbits, magnetic fields, or other volumetric data that are invisible to the human eye, but still follow the line of cognition.

4.5. Cartography as a Knowledge Instrument

The history of geographic visualisation “has provided for over a millennia uniquely powerful instruments by which to classify, represent and communicate information about space which is too large and too complex to be seen directly” (Dodge, Turner, & McDerby, 2008, p. 2). Geographical maps show both geographical locations and the networks between them: rivers and roads, trade routes, and migratory paths. They also show networks of relations that separate them into discrete units, for example national boundaries or grids of measure, such as longitude and latitude. Dr. Martin Dodge et al. (2008) senior lecturer in human geography further state that geographical visualisation is as significant as the invention of language and mathematics. Already in the early days of Western society, it allowed for the organisation of spatial knowledge, facilitating navigation and controlling territory. (Dodge et al., 2008)

Philosophically, maps help us to define our experience of navigating a common space (Akerman & Karrow, 2007). This space is created by coordinates that provide insights into proportion, size, relation, and localisation. Through maps we are able to localise ourselves in the world, giving us a haptic awareness of our surroundings. It enables us to see and travel in our minds. Virtually any map of the earth could serve as an example. Here the map of the world from Plate LXXVII has been chosen, because, being created in 1771, it also expresses the

cultural spirit of that particular time, as well as how the world was perceived (Figure 4.17). During this time, significant discoveries that helped to map the earth were made by ships circumnavigating the globe—a task taken up by the satellites of today. Perhaps it is because of these human-scale distances—for example, that which could be travelled by foot or by ship—that historical maps like the one underneath contain a more human-felt spatial knowledge.



Figure 4.17. World Map from Abraham Ortelius's *Theatrum orbis terrarum*. [1570] Photo. Encyclopædia Britannica Online.¹¹

The power of cartography lies in its function as a tool for spatial visualisation. It organises and structures space in a way that enables our mind to envision it.

Brian J. Harley and David Woodward (1987) defined the drawing of maps and the

¹¹ Retrieved from <https://www.britannica.com/science/geography?oasmId=136114>

geographic visualisation of their time as facilitating a spatial understanding of things, concepts, conditions, processes, and even events in the human world.

Underneath is an example of cartography showing different sea and terrain levels via the use of colour (Figure 4.18). Edward Tufte (1997) used these two images to illustrate how easily important information can be misinterpreted through visualisation only. In this case, the wrong usage of colour led to an unreadable illustration; because all colours are bright and very saturated, there is no recognisable hierarchy.

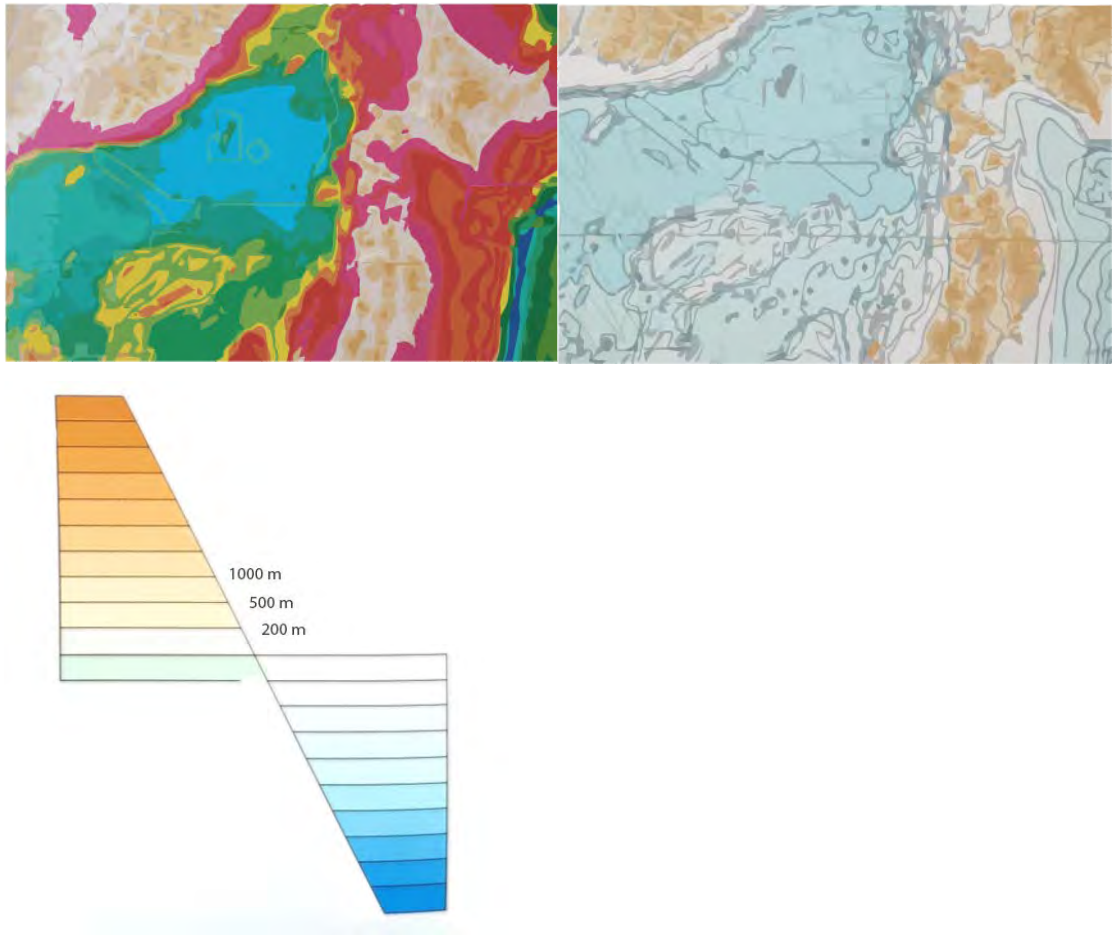


Figure 4.18. Examples on the Japan Sea Map, own graphics, Isabella Beyer, 2018 similar to General Bathymetric Chart of the Oceans, International Hydrographic Organization, 1984, Ottawa, Canada, 5th edition. In *Visual Explanations: Images and Quantities, Evidence and Narrative* (p. 76-77), by Edward Tufte, 1997, University of Michigan: Graphics Press.

Another illustration by Da Vinci, this time a map, serves as an example of how he made it possible to capture a space too large for the human eye to comprehend and made it intelligible and graspable through his visualisation (Figure 4.19).



Figure 4.19. A plan of Imola, Pen and ink, with coloured washes, and stylus lines, over black chalk. Drawing by Leonardo da Vinci, 1502, © The Royal Collection Trust.¹²

Da Vinci's map of Imola proves that he also experienced disembodiment: whilst imagining Imola from above, since he could not fly to gain a bird's-eye view, he had to be capable of disembodiment, closing his eyes and imagining he could fly and look down on the town. Da Vinci further combined his imaginative bird's-eye view with his knowledge of paths: with the help of his instruments, using a hodometer and a magnetic compass in order to draw the "Town Plan of Imola," Da Vinci created this "ichnographic" map; the earliest of its kind in existence (Bliss, 2016).

¹² Retrieved August 21, 2018, from

<https://www.royalcollection.org.uk/collection/search#/2/collection/912284/a-plan-of-imola>

4.6. Disembodiment and Artistic Enlightenment

Whilst scientists try to embody all objects of knowledge and aim to see through their mind's eye, some artists on the contrary try to disembody themselves in the process of creation.



Figure 4.20. Reconstruction of Filippo Brunelleschi's experiment linear perspective. Museum Galileo Florenz. In: Michael Hutter. *Ernste Spiele*. (p.41)

The two images in Figure 4.20 illustrate Filippo Brunelleschi's artwork and his notable experiment regarding linear perspective in front of the Baptistery of Florence in 1420. In this experiment, Brunelleschi looks into a mirror through the hole in one of his own paintings, thus seeing himself inside his own artwork. Through this experiment, Brunelleschi was able to prove that, through the use of a linear perspective, a realistic three-dimensional illusion can be created on a flat surface. Or, as Kemp (2000) points out, "he was establishing a mode of

depiction [or a visual language, one could suggest] that was ultimately to affect the conveying of visual imagery in virtually every field of artistic, scientific, and technological activity” (p.28).

Just like Kemp, we are today distant benefactors of Brunelleschi’s vision when we look into the invisible “boxes” of space behind our flat mobile screens. Luis Miguel, my PhD fellow at the Planetary Collegium, translated the experiment into an exercise of disembodiment, separating the artist from his own body since he can see himself in the artwork. Miguel further explained during his presentation at COST conference in Zagreb 2013 that this not only changes the point of view—stimulating a different perspective, freeing the artist from his or her physical constraints, and allowing him or her to experience disembodiment—but also the self-constitution and spatial relation of being somewhere else in the world (Miguel, 2013).

In an attempt to describe how subjectivity might possibly be integrated in the generation of knowledge, Miguel (2013) identifies that, in the artistic process, so-called “out-of-body” experiences are crucial, since they allow for new perspectives, whilst transforming our consciousness. The artistic work can be elevated to a portal—a passage moment, enabling meta-observation. Taking this argument one step further, I suggest that a work of art can serve as a passage experience for anyone interacting with it, inhabiting the same out-of-body experience.

4.7. From Heuristic Instruments to the Cognitive Living Things

Bauer and Ernst (2010) understand visuals such as diagrams as heuristic instruments that are primarily human-made imaginations of the environment, attuned specifically to the human perception system. For the development of provisional interpretations, each technique or medium is—and must be—tailored to the human perception (Bauer & Ernst, 2010, p. 261). Further, in constructivist theory, Bauer and Ernst argue, not only visuals, but also theory, science, and knowledge—or, in other words, everything we know about the world in which we live—is a provisional human construct. With this observation, the authors compromise, reducing the visual to only its representational function—a stance with which I fundamentally disagree. In my view, visuals can become much more than provisional heuristic instruments; they can evolve into tools of thought. Already the constructivists made apparent that human-made heuristics or visual models can become foundations of whole scientific fields upon which society can orientate itself, whether we look into patterns of time, maps, or the separation schemata of degrees of latitude and degrees of longitude.

Visuals can be themselves knowledge experiences and even generate new knowledge, especially in the sense of experienced knowledge. Immersive media technology can enable and support the transformation of the image knowledge, so that this knowledge can be formed into “experienced” knowledge (Heßler, 2006). Thus, I would like to expand the idea of heuristic instruments to include experiences and interactions. In my concept of *Le Passage* as outlined in Chapter 2, the enaction of knowledge can not only take place through the

environment, but also through concepts or visual artefacts, which indeed help us think. Malafouris (2013) illustrates this framework as follows:

“Consider a blind man with a stick. Where does the blind man’s self begin? At the tip of the stick? At the handle of the stick? Or at some point halfway up the stick?” (Gregory Bateson, 1979, p. 318, as cited in Malafouris, 2013, p. 4) Or does it end at the biological boundary of his skin? The blind man experiences the world through the tip of his stick, and the stick extends his system of perception. The stick can be a physical tool or it can be a visual construct, which helps to extend our senses and reasoning.

We should look for these experiences of passages by shifting our focus away from the sphere of isolated and fixed categories—such as things, objects, separated time frames, and spaces—to the sphere of fluid relations between minds and things. In this sphere, “minds and things are in fact continuous and interdefinable processes rather than isolated and independent entities” (Malafouris & Renfrew, 2010, p. 4). Here, the moments of blending, transition, and passage can be found, and it is here that the most exciting things happen, forming our personal sphere of knowledge.

4.8. Conclusion: Science and Art

The aesthetic techniques deployed for artistic visuals and scientific ones can be at times quite similar. In other words, both art and science have specific areas in which their potential to meet is most promising, and can result in more valuable outcomes.

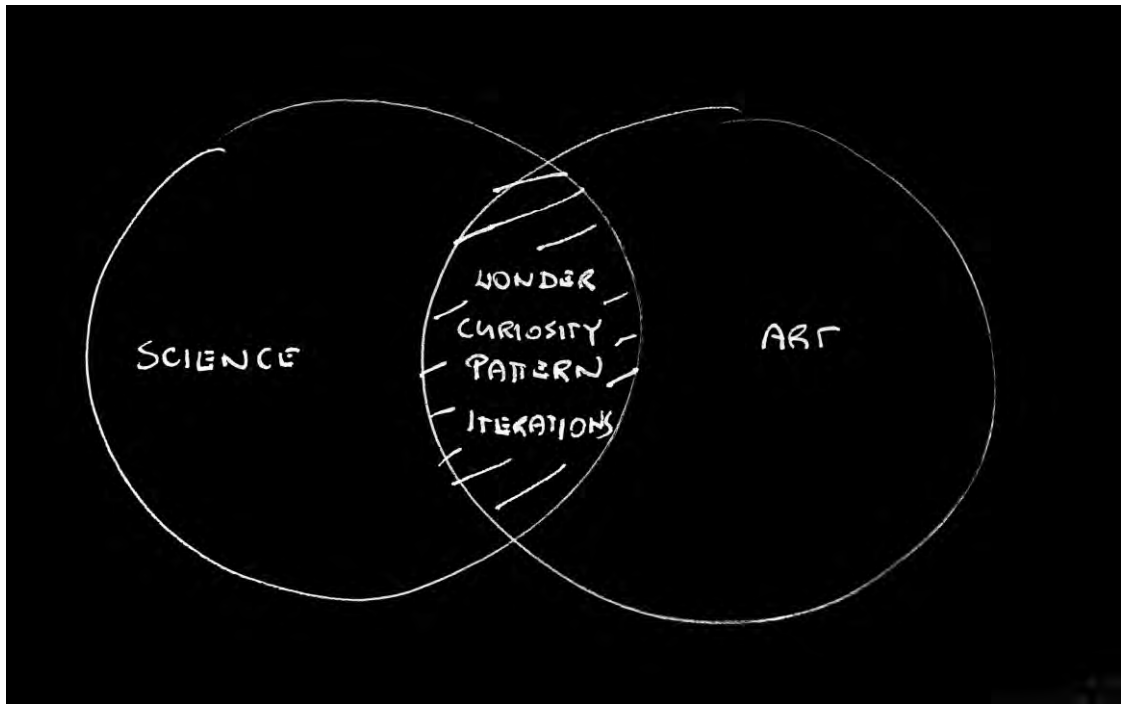


Figure 4.21. The creative meeting point between science and art. Drawing by Isabella Beyer, 2018.

Both fields share the creative moment that is so necessary in order to develop new knowledge. It is this perfect moment of wonder that causes openness, curiosity, and creativity, and therefore the intuitive willingness to create.

Furthermore, it is the moment of wonder in which the fields of both science and art share the greatest overlap (Figure 4.21).

It is therefore a necessity for both fields to realise this shared trajectory, and open themselves towards each other, becoming more transparent and revealing their processes of new knowledge production—to find these moments of intersection. These moments of intersection can then be expanded to nodes, which are the creative moments and active moments of creation—moments that can also be described as transitions, similar to the metamorphosis of a concept

that is in transition, being added to, manipulated, tested, being taken apart, and then rebuilt again.

It is a process that is highly vulnerable to censorship and judgement from the outside world. Yet, this vulnerability needs to be overcome for the sake of transparency, co-operation, interdisciplinarity, and the production of new knowledge—in order that we might deepen our understanding of the world we live in. To put it in Robert May's (2000) words, in his review of Martin Kemp's book (a collection of his essays previously published in *Nature*): "I have always found it foolish to draw distinctions between the creative arts and the creativity found in science, engineering, and technology" (back cover).

5. The IDE: The Taxonomy of a Knowledge Instrument

5.1. Introduction: The IDE and Its Taxonomy

In Chapter 5, the digital space was evaluated as an important environment for the passage experience. In this chapter, the Immersive Dome Environment (IDE) itself, where the experience takes place, will be broken apart into its different functions, parameters, and taxonomies in order to analyse its function as a visualisation instrument and evaluate its potential to further processes of imagining and understanding.

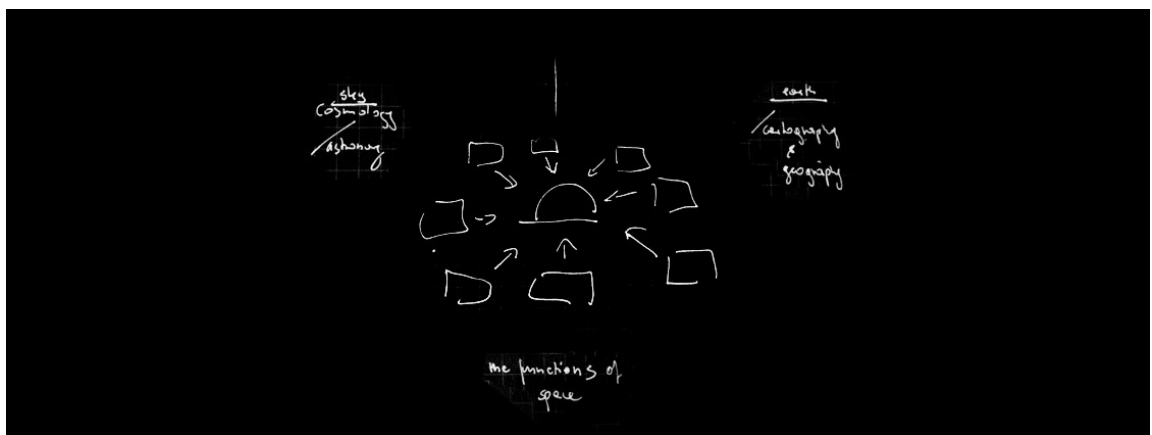


Figure 5.1 The IDE as an instrument. Sketch by Isabella Beyer, 2015.

The IDE has its roots in the history of the planetarium, the globe, and cartography—as seen for example, in the Globe of Gottorf (see section 1.1.1 of Chapter 1). Historically, the two main topics were the sky and the earth, and it seems natural that these two elements remain the most frequent ones to be

represented today in digital IDEs around the world. Sciences of the sky, such as astronomy and cosmography, and the earth sciences, such as geology—including oceanography and volcanology—are commonly presented in the IDE (see Figure 5.1). Additionally, knowledge visualisations concerning space, such as spatial cartography, are enhanced within the spherical arrangement of the dome. The content displayed can vary from flat or volumetric cartographies to micro and macro environments. Most of my own 360° productions are based in the fields of astronomy, cosmography, or both onshore and offshore geology. My latest production—“Superhelden der Ozeane” (Superheroes of the Deep Sea)—reached the deepest oceans, as seen here displayed inside a mobile dome in Figure 5.2/Figure 5.3.¹

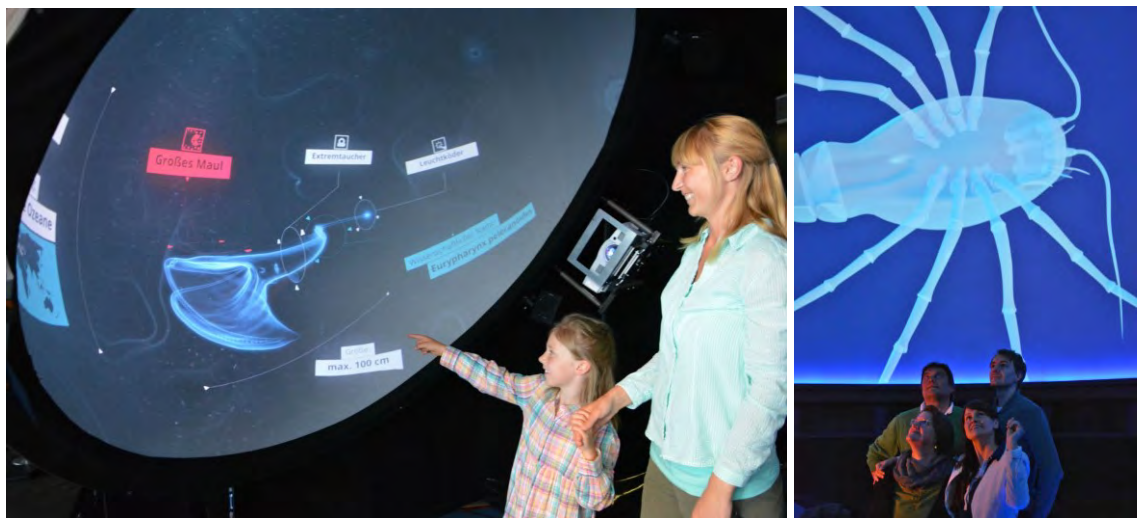


Figure 5.2. The mobile dome (IDE) at our exhibition in Kiel, showing my production “Superheroes of the Deep Sea,” 2017 (left).

Figure 5.3. Pre-visualisation from “Superheroes of the Deep Sea” in the Mediendom (IDE), Kiel, 2017. Photographs by Eduard Thomas, 2017 © Eduard Thomas.

¹ A list of all 360° productions and some image extracts are included in the Appendix of this dissertation.

One question that I would like to explore specifically in this chapter is what additional value the IDE offers through visualisation—in the sense of an insight or a deeper understanding that cannot be reached through any other medium. Through my work on this dissertation, I realised the added value of the dome when it becomes a visual instrument in itself, as illustrated in Figure 5.4.

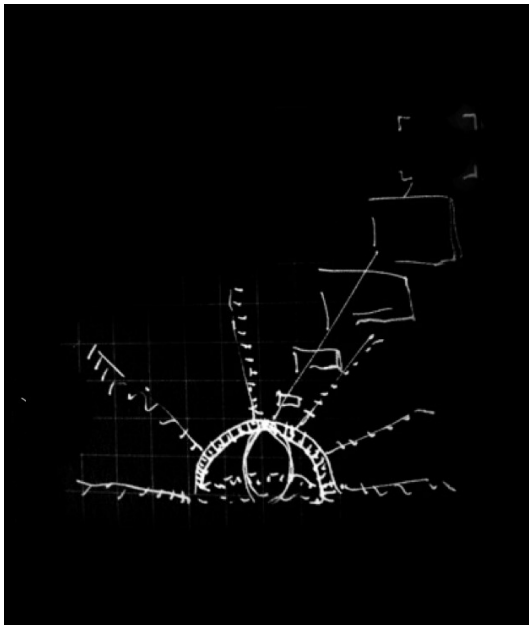


Figure 5.4. The IDE as an instrument. Sketch by Isabella Beyer, 2015.

Through my research, I identified that this encounter of deeper understanding can happen in two stages: either in the creation process—when the spatial knowledge of the designer shifts and he or she gains a new perspective of a given concept, as described in subchapter 1.3—or through the experience of being inside the medium itself, allowing an exchange between cognition and the visual input during a passage or transition—as explained in Chapters 2 and 4.² Obviously, in order to successfully transform the IDE into an instrument of cognition, it needs to be used as an instrument beforehand by the designer

² See Chapter 4 Tools of Thought for more information on the passage experience and the cognitive life of things.

preparing the content for display. The sensitive designer who creates such an experience for the IDE environment has a rich repertoire of instrumental characteristics and techniques that need to be used very carefully, in an exact and sensitive manner. These characteristics will be elaborated upon in the proceeding sections.

5.2. Empowering the Designer Through the IDE

Firstly, simply being allowed to design for this extraordinary space feels like a privilege for a designer or artist. It offers so much freedom for expression and an (almost) infinite space to use for one's own creations. I presented the image presented in Figure 5.5 at Plymouth University in order to make the IDE's scale graspable by comparing different available screen sizes.

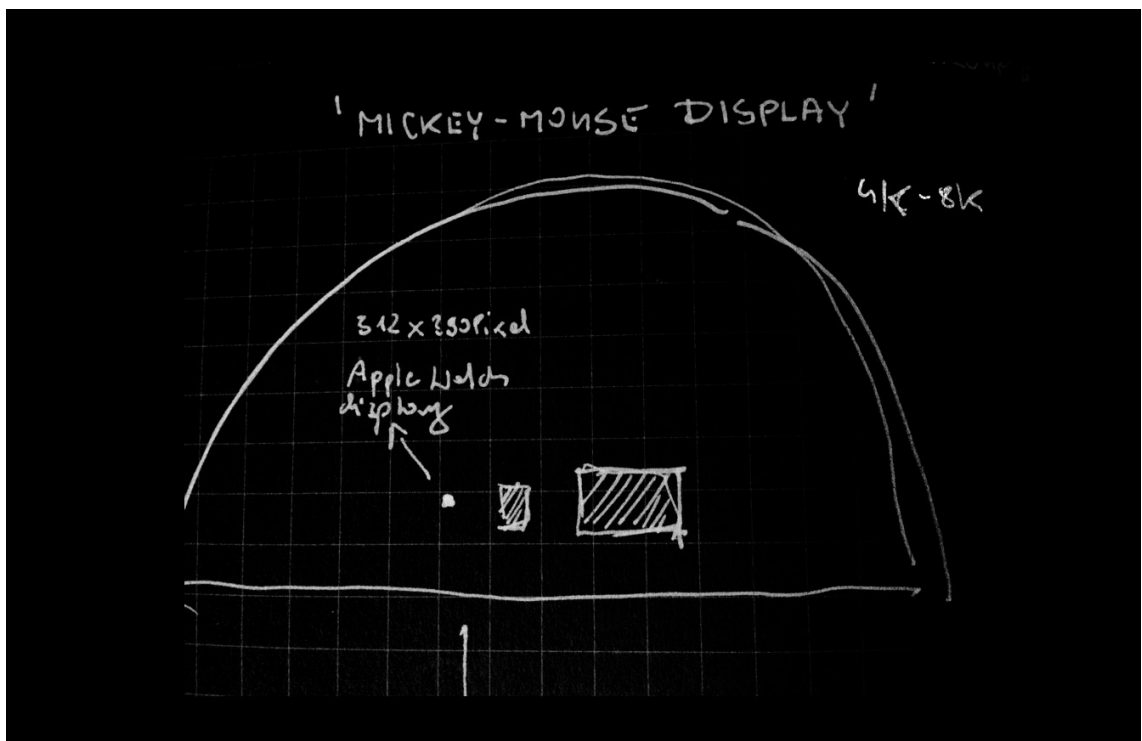


Figure 5.5. The IDE in comparison to other displays and resolutions. Sketch by Isabella Beyer, 2015.

The comparison involves an Apple Watch display of 312 by 390 pixels, a standard mobile phone display, a TV screen, and the dome's inner surface, which can reach up to 8000 by 8000 pixels and therefore currently offers much more space than other media formats. Additionally, this canvas occupies a spherical space around the viewer, rather than the limited, flat TV or cinema screen in front of the viewer. This spherical characteristic creates great challenges for the designer regarding the creation of content, as there is no obvious defined orientation—in front of the lens versus behind the lens—and everything can be seen. This is especially difficult when shooting live sequences with a fish-eye camera: Where to hide the equipment? How can the actors appear without being seen too early beforehand? Also, in a three-dimensional scene, canvas tricks for backgrounds cannot be used as one would for rectangular formats, because the camera is omnipresent. Everything needs to be modelled and fully created, because it will be seen from almost all sides. Therefore, designing the space for the IDE requires good planning in advance.

In order to realise this huge spherical space as a designer, I have developed several hands-on techniques throughout the different production phases. I would like to present them here, accompanied by clear visual examples. These techniques not only help the designer to create content for the spherical space, but can also mediate potential conflicts between artists and scientists when working collaboratively on projects. For example, scientists might not fully understand the spherical space and its capabilities, and thus be unable to imagine what can be expected from the final visualisation of their data. Conversely, the artist or designer creates and prepares a visualisation in

elaborate detail, for example in the form of an animation, and assumes that once the work is complete and can be displayed inside the dome, the process is complete. Often, when the scientist sees a visualisation for the first time inside the dome, any initial scepticism immediately vanishes and he or she is impressed by its power. The scientist now becomes creative and develops further ideas for, and corrections of, the visual content. Yet, it is in this moment that tension between the scientist and the artist can arise. Visualisation companies in particular aim to be very efficient and thus, there is no time for the experimentation that would be required to create truly convincing output that would satisfy the creator, the scientist, and especially their audience. Experimentation is often the key for convincing creations. In order to avoid this situation, there are several production phases and techniques that allow artists and scientists to collaborate before the final animation is displayed inside the dome, at which point it is no longer possible to make any changes because they would be too time consuming and expensive.

Having encountered and observed similar conflicts many times, I have developed the following workflow and techniques. The designer never creates the final product on his or her own, working instead in close collaboration with scientists and other persons involved in the production phases, exchanging the status and final milestones accordingly after each phase—from the first script to the storyboard; mood boards;³ final moods; several animatic stages with, for

³ Mood boards represent a general visual approach and consist of many images, whereas moods consist of one circular image and are the final style guides for the final 360° film.

example, an audio file; the final movie without soundscape; and ultimately the final movie with the final sound mix.

5.2.1. 360° Storyboarding

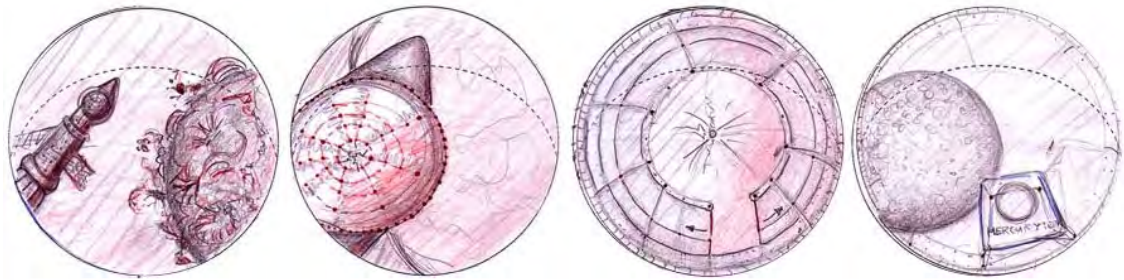


Figure 5.6. 360° spherical storyboard for the show “The Problem with Pluto,” Melbourne Planetarium, Isabella Beyer, 2005.

First, the designer collects reference materials—such as images, videos, and descriptions of the topic to be visualised—and exchanges ideas with the scientist(s). These ideas and materials are then collected textually, for example in an online document that can be communally edited by all concerned. Once both designer and scientist agree on the content blocks, the designer starts to divide them into scenes and possible transitions, drawing the storyboard.

In order to plan the scenes and transitions according to the script in my own projects, I use circles to lay out the whole 360° scene, each circle representing one scene. These circles result in a drawn storyboard consisting of many spherical drawings (Figure 5.6). Scenes that have to contain many visual objects are drawn to a larger scale. The planning for VR applications and 360° VR shots

can be represented in the same way. This way of drawing helps one to envisage a spherical VR scenery.

However, it is important to be mindful of the fact that in VR, we have a full sphere, and the opposing, lower cupola always needs to be considered and/or added visually. In order to solve the problem of visualising the bottom area in one circle, distortion can help. Via a distorted drawing, the bottom area can also be integrated in the spherical drawing, as can be observed in Figure 5.7 and Figure 5.8.



Figure 5.7. 360° spherical storyboard image for the project “Cuve-Waters,” Frankfurt, Isabella Beyer, 2013.

The storyboard presented in Figure 5.6 was developed for the project “Cuve-Waters” and was produced in a collage format, in which drawings and existing images were blended. Here one can recognise the orientation of the spherical environment, the bottom of the circle showing the three rows of plants

representing the front of the dome, and the centre of the circle the dome's zenith.



Figure 5.8. 360° spherical storyboard: From images to mood boards for the show "Dream to Fly," Isabella Beyer, 2013.

The 360° storyboard helps one to envisage each scene and its transitions in the spherical environment. Additionally, the storyboard provides an initial visual overview of the entire 360° show. In Figure 5.8, one can see how a drawn storyboard can slowly unfold in colour and thus convey a feeling or mood, giving an overview of the final visualisation.

5.2.2. 360° Mood Boarding



Figure 5.9. A mood board image for the German production “Die Drei Fragezeichen,” Isabella Beyer and Natalia Oliwiak, 2017.

Another technique—the use of 360° mood boards—as illustrated in Figure 5.9 provides both a finalisation of the aesthetic and the visual style of each scene, additionally giving guidelines for the colour, perspective, and feel of the final film. The use of a mood board provides a crucial guide for the whole production team and can be used as a point of orientation, allowing for a visual “golden thread” to run through the whole 360° film.

Figure 5.9 shows a mood board I produced for a well-known German audio-drama entitled “Die Drei Fragezeichen” in 2017. I created 21 high resolution scenes in my art direction work.⁴ The challenge was to create scenes that spoke emotionally yet without revealing too much of the characters and the overall

⁴ The work was accomplished for the company Northdocks in Kiel, H03RRAUM Media GbR and Sony Music Entertainment Germany GmbH. The premiere took place in 2018 at planetariums in Kiel, Hamburg, Berlin, Bochum, and Jena.

story. The scenes were intended to be complemented individually by listening to the audio-drama, imparting a visually blurred, mysterious quality. The characters in the play, if present at all, only appeared as silhouettes or shadows. The concept of this production was very exceptional and [for me] quite intriguing. For most human beings, the unseen or unknown are most thought provoking, and it is the same for me—it was a pleasure to work through the unseen for each scene and to stage it in the proper light and colour. Each recipient is then free to bring one's own imagination into play, completing the story in one's own mind.

5.2.3. 360° Animatic

The very first animatic can already be achieved by putting the drawn storyboard and the first spoken text together into a moving image; a film sequence for the whole show. After each scene is roughly set—meaning the perspective and all things that ought to appear inside of it have been determined—one can decide how the scenes should be created, either in a two- or a three-dimensional animation, or with real-time tools. In a three-dimensional program, the 3D animation is built, including camera movements and three-dimensional models. These models should initially have only a rudimentary grey colour shading, so as not to distract aesthetically from the creation process—its movement and shapes—which has to be established before each model acquires more detail. Only when the scenes become more complex can lighting and shading be finalised.

Importantly, throughout the creation process the animatic has to be constantly updated, and an overview of all scenes needs to be kept in mind in order to ensure a coherent visual style. The storyboard images are substituted by the first animations of each scene, which are subsequently updated during each more elaborate stage of the animation until a final animatic is reached that includes all scenes, ultimately resulting in the final 360° film. After each production phase, an exchange with the scientist(s) or other involved persons should take place. This collaborative exchange ensures that a common consensus is reached and followed through the whole production. In this way, it is possible to create a visualisation that pleases everyone and lives up to the expectations of all the parties involved in its creation.

5.2.4. Prototyping

If interactive experiences or even 360° games are planned instead of the animatic versions, a different technique—that of prototyping—is needed. This entails the creation of a prototype of the final experience, only with lower resolution, and with only basic models and environment, yet providing a full run-through of the interactive stages. Interactive stages are exact simulations in which the viewer can influence the projected environment via body movements or another sort of input (for example, via controls or mobile phones). The prototype can then be tested and optimised until the final product is achieved. Prototyping and experimentation are two of the most important ingredients in the creation of a unique experience.

5.3. The IDE's Taxonomies

In addition to the 360° design and production techniques described, it is important to analyse the IDE's specific visual characteristics, which are invaluable and need to be understood if the designer is to create the most valuable experience or encounter for a specific topic—one that is specifically designed for the IDE and its audience. Through my own work producing over 20 fulldome productions since 2003 and my work with students at the University of Applied Sciences in Kiel and the University of Applied Sciences in Karlsruhe, I have compiled the following list of taxonomies—in the meaning of characteristics—that are very specific to this medium.

Interestingly, some of these characteristics are paradoxical, enabling something important—such as a new perspective, insight, or other perceptual sensing—whilst simultaneously disabling something else. The resultant repertoire of characteristics should be revisited whenever designing a creative encounter for the IDE. The characteristics have been divided into the categories of creation and experience, and will be explained in more detail in the two proceeding subsections. discussing the following taxonomies:

5.3.1. The IDE's Creation Taxonomies

5.3.1.1. Creation: False Distortion or New Perspectives

Most inexperienced, first-time viewers of spherical environments need some time to adapt to the distorted image of the dome. I have had several discussions, especially with academics working in the field of cinema studies, who are most

critical about the spherical distortion, some claiming it could even be considered as a falsification of the image itself. To this criticism I ask: How can a spherical image be a falsification? Is it not capable of encompassing its own level of effectiveness? Should we not also consider the possibility that a flat image is a falsification—simply one that is more common and thus accepted?

When considering notions of falsification or the opening up of new and multi-layered perspectives, one needs to take account of the well-known artists who spent their lives trying to master the representation of spherical space on a flat paper. One of them, working for a significant period of time with spherical glass bowls, was the Dutch graphic artist Maurits Cornelis Escher. His drawings were mathematically inspired, resulting in compositions featuring impossible objects, studies of perspective, and explorations of infinity. In the lithograph presented in Figure 5.9, one can see three spheres. In one of them Escher looks back at the observer, whilst in front of him, the same three glass bowls can be observed. The image presents a recursive perception and therefore appears as an infinite process or visual loop.

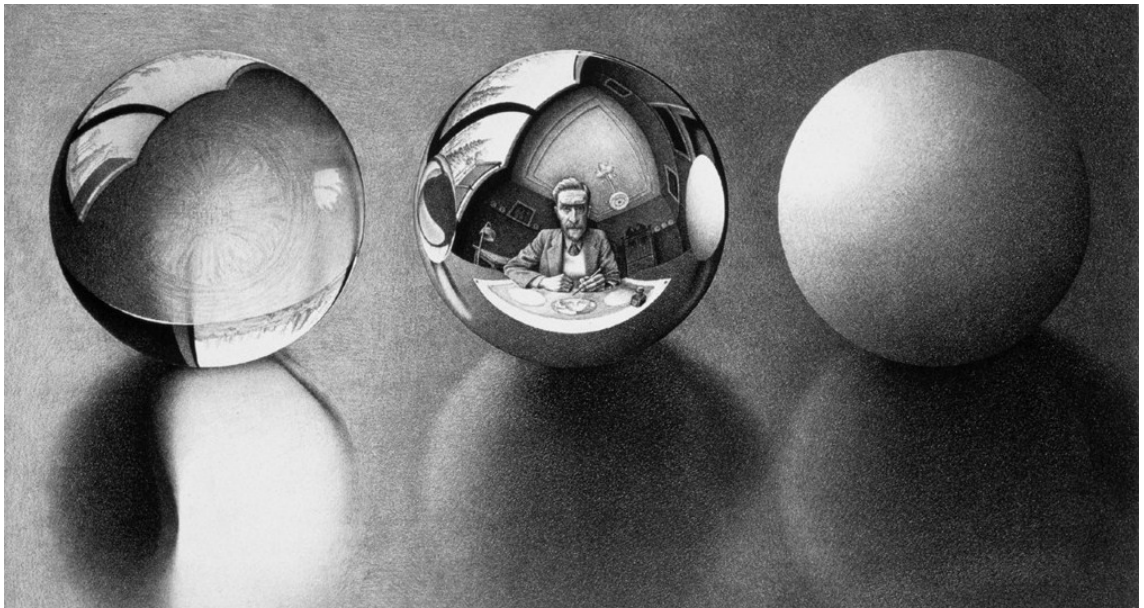


Figure 5.10. Three Spheres II, lithograph by M. C. Escher, 1946 .

The contemporary American artist Dick Termes creates and develops what he calls “Termespheres,” playing with apparently infinite spiral structures on, and inside, spheres (Figure 5.10), as well as many other themes.



Figure 5.11. Dick Termes in his art gallery. Source: Wikipedia.

Termes teaches us how to master the spherical perspective by increasing the number of vanishing points from one to six (Termes, 1991, p. 290). Ultimately, the addition of the sixth point enables us to express the spherical space, as seen in the last illustration of Figure 5.12.

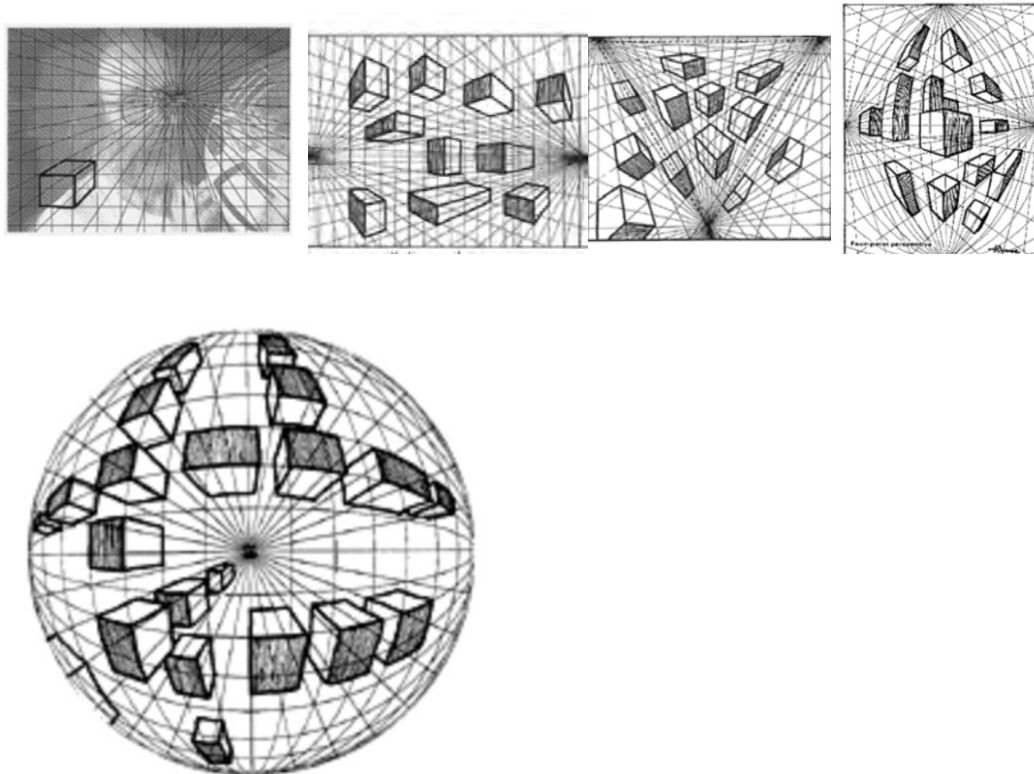


Figure 5.12. One to five-point perspective. Drawings by Dick Termes, 1991.

This last image presented in Figure 5.12 actually has five perspective points. Termes (1991) explains that this is, however, in fact a six-point perspective, the sixth viewpoint being our own. He further adds: "I think of our visual world around us in terms of the inside or concave surface of that sphere" (Termes, 1991, p. 290). Therefore, the spherical visual can be seen as an enriched

knowledge space or volume space, including multifold perspectives such as those employed in these examples, which illustrate up to six points of view.

Following Termes, I understand our perceptual system and the process of how we perceive the environment around us as spherical—as a sphere of perception that follows us everywhere we go. In other words, our perception of the world is based on this spherical schematic.

5.3.1.2. Creation: Black Infinity in 360°

The success of the planetarium is based on an optical illusion. In other words, it is based on the weak human perception of spatial depth. Due to the symmetrically curved surface, differences in depth between the eye and the black surface between the stars cannot be distinguished. In addition, the darkness of the planetarium takes away the scale of depth, and thus any possible point of reference. All that can be seen are sparkling stars in an undefined black space. Therefore, the planetarium environment creates the illusion of infinite space with ease. As the recipients are preconditioned by their experiences of cinema—which uses black for transitions and cuts between the scenes—this function can easily be adapted for use inside the IDE.

However, if the black remains for too long, it can appear somewhat unnatural—even though sound can still be heard, the audience may start to feel anxious, thinking the system has broken down or a mechanical disconnection has taken place. Overall, black and dark scenes serve this medium well, evoking a sense of being present in the spherical image. Yet, when the image becomes too bright,

the structure of the dome and the surrounding environment appear, which minimalises the effect of being present in the virtual environment.

5.3.1.3. Creation: Outer or Inner Perspectives?

The IDE favours both external and internal perspectives, so it is possible to map the earth on the concave surface of the cupola, such as in the Georama (see subsection 1.1.2 of Chapter 1). This enables both an inner perspective on the earth, whilst also allowing it to be observed from the outside, as illustrated in Figure 5.13.



Figure 5.13. Earth from an outer perspective, rendered with Uniview (SCISS) and earth from the inner perspective, Isabella Beyer. 2013.

Recalling Termes's work, the spherical canvas is key to the total visual environment. It opens up new possibilities by which to understand and exchange knowledge about otherwise completely enclosed spaces (Termes, 1991). Similar to Termes, I believe that the unique inner and outer perspective capabilities of the sphere—by illustrating the world “inside out”—creates this unusual wholeness for the viewer, which cannot be achieved through any other medium.

This volumetric, visually full environment enables the viewer to perceive both the inside and the outside of a given object via a single medium. Or, in Termes's (1991) words: "As spherical geometry is different from planar geometry, so too is the spherical canvas different from the flat canvas. Once an artist or an observer has entered that new dimension, it is very hard to come back" (p. 292). As an artist, I support Termes's last phrase: I too will never return to the flat surface. However, I do believe that future media formats need to become more natural, spatial, and able to surround us in a full 360°.

5.3.1.4. Creation: Peripheral and Foveal Vision

This section tries to answer the question of whether it is more important to orientate the audience by using foveal vision (focused vision) and limiting the peripheral vision, or to use peripheral vision and limiting the foveal. Figure 5.14 below illustrates foveal vision—a narrow, focused, and sharp field of view represented by the red line—whilst peripheral perception appears blurred, represented by the blue field.

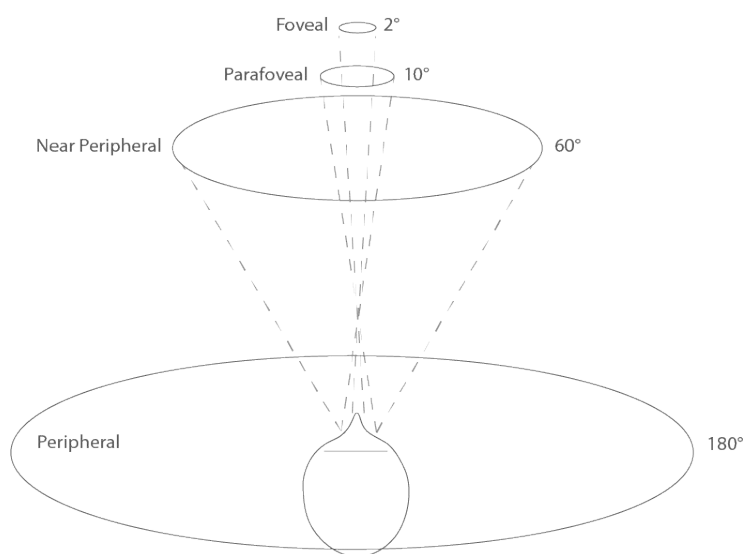


Figure 5.14. Foveal and peripheral vision. Illustration by Isabella Beyer, 2018 similar to Robert Solso, 1994 (c) MIT Press.

The interplay between peripheral and foveal vision inside the IDE is quite intriguing, as the peripheral field in particular can be very successfully manipulated inside the 360° environment. The designer has a significant amount of freedom to prepare the senses for the next visual input and work with the viewers' peripheral vision. Most 360° productions choose to have a sweet spot—usually the lower middle section at the “front” of the cupola - in order to lead the viewer safely through the whole program.

However, if the whole show is presented within this limited “front” area, the visual can appear quite static, giving rise to the question of why it was at all produced for the spherical environment, and not simply for the flat canvas of the cinema. Foveal seeing can be orientated towards the sweet spot, but should also lead the viewer at least across the 180° degrees from the right to the left of the “front” of the cupola during a programme. Additionally, foveal vision should be enriched by, and exchanged with, the peripheral surrounding. For instance, very slow, gradually developing movements in the peripheral visual field that cannot be observed through the foveal vision can have quite an intense impact on the senses and on the recipient in the long term inside the cupola environment. Such movements can only be felt via other senses, including peripheral vision, excluding the foveal eye.

A good example of minimal movement with high impact is the project and performance “Liminal Spaces,” which was performed at the Society of Art and Technology (SAT) in Montreal, 2016. Inside the Satosphere—the dome at SAT—there were no seats. The audience had to stand, and in-between the members of

the audience ship containers were positioned, which could also be seen in the projection on the dome's surface. At the beginning of the show, nothing seemed to happen at all, but in reality the containers on the cupola were moving very slowly on the periphery, all-around. This movement could only be felt via peripheral sensing over time, because in the narrow foveal field no direct changes could be observed. After some time, when the audience had become aware of the movement, the containers standing in the dome were slowly moved by performers in accordance with the image (see Figure 5.15).



Figure 5.15. Performers in the show "Liminal Spaces," SAT, Montreal, 2016.

Emerging from the dome, I felt a little dizzy, as if stepping onto solid ground after a boat trip. It was a very affective experience. Sometimes the unconscious feeling of environmental change can be much more intriguing and have longer lasting effects than simply feeding the viewers' foveal vision with information.

5.3.1.5. Creation: Eyes of the Skin

After experiencing "Liminal Spaces," I became very interested in Juhani Pallasmaa's (2005) work and his concerns regarding the bias shown to vision, and the suppression of other senses (p. 10). Pallasmaa analysed the role of peripheral and unfocused vision in people's lived experiences of the world, as

well as people's experience of interiority in the spaces they inhabit. He believes that "[t]he very essence of the lived experience is moulded by hapticity and peripheral vision envelops us in the flesh of the world" (Pallasmaa, 2005, p. 11), whereas focused vision confronts us with the world.

Authors such as Pallasmaa believe that all the senses are best understood as extensions of the tactile sense. Therefore, all sensory experiences, including vision, can be defined as modes of touching and are thus related to tactility. Further, touch is understood by the anthropologist Ashley Montagu as "the mother of the senses," and the skin as both the most fundamental and most sensitive of our organs (Montagu as cited in Pallasmaa, 2005, p. 11). Most importantly, Pallasmaa (2005) explains that touch integrates our experience of the world with that of ourselves. All this happens, of course, inside and via our bodies. The body is the locus of perception, thought, and consciousness, as well as a point of further reference for memory, imagination, and integration, since it remembers who we are and where we are located (Pallasmaa, 2005).

Pallasmaa (2005) argues that environments such as forests as well as complex architectural spaces provide intense stimuli for the peripheral vision—these stimuli centre us in such a space. The same concept applies whilst leading the viewer through a complex modelled space in the IDE. Through the complexity of the object itself and the additional field of view (in the case of the IDE, 360°), the full level of stimuli for peripheral vision can be reached. The perceptual realm beyond the scope of focused vision is as important existentially as the focused image—indeed, medical research has suggested that peripheral vision has a

higher priority in our perceptual and mental system than foveal vision, so that objects perceived through the peripheral vision can be better memorised (Pallasmaa, 2005).

Pallasmaa (2005) states that new architecture is missing the field of perceptual vision, making the viewer feel like an outsider, in contrast to historical or natural places: “Unconscious peripheral perception transforms retinal gestalt into spatial and bodily experiences. Peripheral vision integrates us with space, while focused vision pushes us out of the space, making us mere spectators” (p.13). A forest, for example—which is also a virtual, three-dimensional world and can be quite complex in the IDE, using peripheral vision—is similar to architectural reality. In a way similar to architecture, content visualisation in the IDE should address the body and all of its senses simultaneously in order to enable a truly enriched experience, fusing our self-image with our experience of the world. The IDE should articulate the experience of being-in-the-world and strengthen our sense of reality and self-constitution, as well as our relation to our own body.

5.3.1.6. Creation: Sensational Carousel Rides or Slowing Down

Is the IDE only a medium for sensational carousel rides, or can it also be used to decelerate and slow down the world around us? The slowing down effect appears because of the sheer size of the medium and its visual appreciation thereof, which needs time to evolve around the recipient, as described in section 6.3.1.4 on peripheral and foveal vision. The viewer also needs time to perceive the visual in its entirety. Yet, because fast carousel rides are quite successful in this medium, the obvious question arises as to why that would be the case.

A fast, looped carousel ride might appear trivial, but such experiences can profoundly affect the viewer—as long as the problem of motion sickness is carefully managed. I remember a discussion in Berlin with other experts working in the fulldome field (personal communication, 2013). There were many concerns regarding looped tunnels and how overloading for the senses the experience could be—indeed some even asked whether they should be forbidden (personal communication, 2013). Yet, everyone working in a planetarium environment knows how much children and adults enjoy such rides, even if for little more than to test their courage and to have a thrill, maybe even to feel more alive and (re)connected to their bodies—motives similar to those that prompt visits to amusement parks. Indeed, from only a quick look at the growing number of visitors in amusement parks, it seems to be something that many different people enjoy experiencing. In our 360° film “VIP”—an entertaining music show—tunnel rides were employed for passage transitions between the scenes in order to wake up the public and prepare their senses: the darker, narrow surroundings of the tunnel—thus minimising the visual input—allowed them to appreciate the visual landscape even more once they had slipped from the tunnel into the next, completely new 360° scene.⁵ Thus, both the slowing down and consequent visual appreciation, as well as specifically designed

⁵ The minimising of input for the senses can be a quite important tool. When visiting the exhibition “Dialog im Dunkeln” [Dialogue in the Dark] Dialogue Social Enterprise GmbH, 2018 in Hamburg, I experienced the intensity of such an environment. The exhibition tried to provide insights into the lives of the blind, and thus the entire experience was conducted in total darkness, not providing the sense of sight with any input at all. It was a very calming encounter, sensitising all of the other senses.

carousel rides effecting corporal awakening and the minimalising of visual input, can be important instruments.

5.3.1.7. Creation: Explorative Autonomy or the Loss of Orientation

Whilst viewers gain a degree of autonomy inside the IDE to explore the whole 360° visual space, at the same time, they need to allow for a certain loss of orientation and be prepared to give up the ability to control the experience themselves. The viewer needs to be fully immersed in the visual environment, to have time to experience it, and explore its different depths. Once a sense of orientation within the image space is established, the exploration process stops. Therefore, this characteristic once again exhibits a paradox regarding these two functions: each function, once fully expressed, contradicts the other. Full autonomy implies less orientation in the 360° space, whilst full orientation implies both the exploration and the feeling of autonomy come to an end: the audience simply awaits a visual change.⁶

5.3.1.8. Creation: All-Seeing View or Path View

When the painter Robert Barker registered a patent for his invention of a 360° spherical image in 1787 in Edinburgh, he promised his viewers an all-seeing view—in his own words “so as to make observers feel as if really on the very spot” (Barker as cited in Meyer, 1993, p. 13). Preparation is needed, however, before such an all-seeing view can achieve its full potential. Movements that are

⁶ Please see the subsection 6.5. Immersion, Exploration and Visual Lead of this chapter for more information on explorative autonomy.

working in opposite directions or that are too fast, thus appearing blurred, can negate the effect.

Thus a passage—a transition—is needed in order for the all-seeing view to reach its full potential. A number of passages have already been described in Chapter 2 on the concept of “Le Passage.” Important here is that both a path-view—that of the voyageur—and an all-encompassing overview are needed for a truly intensive experience and the gaining of a deeper understanding. For instance, when we drive a car along a specific street, we gain a path-view of the surroundings. When we blend this experienced knowledge with the overview—such as a bird’s-eye view of the town via our navigation system—a fruitful connection between both views can be established. The combination of a path-view and all-seeing view can thus result in a deeper understanding, and a spatial construction of, for example, our home town can be built in our mind. This can be realised inside the IDE as well, using the omnipresence of the 360° environment for the overview, and the vehicle function for the path-view.

5.3.1.9. Creation: Scale Comparison, Transcalar Imaginary, or the Loss of Body and Size

The relation between size, scale, and proportion by means of comparison is quite difficult to achieve in a large fulldome environment such as the IDE. The deeper we dive in scale abstraction of either the microscopic or macroscopic world, the more we diverge from our own body and size. Yet, the relation to our own body, which centres our experience of the world, is fundamental to both our understanding and the impact of the experience. Therefore, the question arises of how a reconnection with the body can be created.

In the process of writing this dissertation, it has become evident to me that, in order to establish new spatial comparisons—for example, by introducing an unknown deep sea organism, as I did in the project “Superhelden der Ozeane” in 2007—the use of the dome alone is sometimes not sufficient. Rather, a blending experience with other media formats, such as 3D printing, is needed; an approach that is called “transmedia storytelling” (Jenkins, 2006). First, a single storyworld is created, and from this storyworld different narrative strings are extracted and specifically formed for each individual—yet related—media format. In order to solve the problem of relative scale, small, intuitive, and haptic experiences must be blended with larger, transcalar visual concepts inside the IDE.⁷

5.3.2. The IDE’s Experience Taxonomies

5.3.2.1. Experience: The “Overwhelming” Versus “Sleep” Effect

The visual space inside the IDE can overwhelm the senses to the extent that it can cause the viewer to sit back and fall asleep in their comfortable chair. The challenge for the designer is to create content in a way that keeps the viewer’s brain active, thus avoiding any disconnection between the viewer and the

⁷ Please see Chapter 7 and section 7.5 on “Superhelden der Ozeane” to read more about my case study.

Another project that established this connecting and blending—between the IDE projection experience and small haptic things via interaction—was the project “Murmuration” (2015) by Mike Phillips, which is discussed in the same subchapter.

content. The designer should use concepts of passages instead to lead the viewer from an A to B environment.

5.3.2.2. Experience: Preventing Dissociation and Enabling Inner Reflection

The visual space of the IDE can be quite direct; it is a centric experience that always places the viewer at the very centre of his or her surroundings. Thus, the viewer can only distance him- or herself from the displayed content by closing his or her eyes. Therefore, it can happen that, due to a missing distance or break in the visual input, this inner reflection is disabled. Planetarium shows especially can be filled with too much content or include images that pass too fast, additionally missing both a “golden” narrative thread throughout the story and breaks in which the recipient can relax and regain their sense of orientation. The designer thus needs to plan immersive scenes in which the recipient is fully present, yet include regular visual breaks and space in which the viewer can relax.

Only then is mindfulness—being present with all of one’s senses and in one’s own body inside the IDE’s content—and the time to reflect upon the visual content, made possible. However, our minds are seldom solidly connected with our body and predominantly operate outside of this confinement—whether simply daydreaming, or focusing on mind-based tasks. Varela et al. (1991) explains that, therefore, we are often in a disembodied state; our minds are continuously thinking, revisiting emotional states, passing judgment, returning to situations in the past, and worrying about the future.

He proposes that meditation is needed in order to reach unity between mind and body, and to experience mindfulness; an open-ended reflection, and an experience in itself—a reflective form of experience that allows us to gain an insight into the inner self as well as the outside world (Varela et al., 1991).

I believe that this experience is also attainable inside the IDE. Taking Varela's concept further, it is important to keep in mind that there is always a close correlation between mind and body—one that, if needed, facilitates a rapid return into the fully embodied state. Following the work of the phenomenologist Maurice Merleau-Ponty, Thompson and Varela (1991) also espouse the fundamental idea of embodiment and its double sense, encompassing the body as a lived, experiential structure on the one hand, and as the context of cognitive mechanisms on the other (p. 238).

I believe that the mindfulness experience can be reached via a passage function inside the IDE. Only if we as designers of 360° passage experiences are aware of the function of the body as the context of cognitive mechanisms, as well as of the perceptual radius and distances of usual objects, can we arrange the 360° environment around the body and thus establish a strong relation between the body and the image. This 360° image should be an imaginable and experienceable location, and whilst we are taken further away through a passage, it should still be possible to maintain this relation between our own body size and the virtual environment. Only then can a satisfactory passage be ensured.

5.3.2.3. Experience: Artificial Versus Natural Perception

Is the IDE an unnatural medium and therefore an artificial experience, or an emotional, natural medium of the corporal eye? Due to its spherical perception and real-world properties, the IDE could be regarded as quite natural in terms of perception, allowing for full peripheral vision. This is true especially in relation to VR goggles, the smaller viewing angle of which ranges from only 90° to 110° and thus limits peripheral sensing.⁸ Additionally, VR goggles are quite uncomfortable to wear, thereby limiting a fully immersive experience (see also Chapter 7).

5.3.2.4. Experience: Real World Properties in 360°

Based on the specific properties of the perceptual system and the peripheral vision up to 180°—for example the properties of the projection space, such as the size and the specific geometry during the cupola projection—the projection can be determined as “phenomenally real” (Mausfeld, 2012). Such projections trigger a stronger feeling of reality inside the perceptual system. This affects the epistemic value of the work, because aspects that are classified as “real world properties” are attributed with enhanced epistemic validity. These properties have of course already been used intuitively, mainly in the calculated illusionary interplay between reality and simulation.

⁸ The angle was compared using the following VR goggle types: HTC Vive; Oculus Rift; Samsung VR; and Sony. The whole table chart can be found in chapter 07 VR.

5.3.2.5. Experience: Gaining Autonomy by Encoding Visual Input?

The visual experience in the IDE can only allow visitors to gain autonomy if the designer creates an exploration experience that does not focus on a single sight line concentrated at exactly the “sweet spot” of focused vision throughout the whole film, but rather uses the peripheral areas of the 360° image space as well.

5.3.2.6. Experience: Constructed or Deconstructed Space

During his presentation in Plymouth, 2008, Mike Phillips compared the dome to the cinema, asking which medium best constructs or deconstructs space. As a sequential medium—i.e. one that displays different perspectives via rectangular extracts that are displayed sequentially—cinema deconstructs space. However, this has its limitations, take for example an airport. The cinema would never be able to show the whole airport in one image, whereas the IDE can. Therefore, contrary to the cinema, the IDE constructs space through one, all-seeing spherical image (Phillips, 2008).

5.3.2.7. Experience: Experiencing Pure or Artificial Phenomena

The question of purity in the IDE, and of whether a natural phenomenon or an artificial one is presented, really depends on the interpretation of the term “natural,” necessitating a much deeper analysis—as accomplished in the Chapter 5. My answer, therefore, is that the virtual coordinate space can be understood as real space, as it enables simulations that are truthful in the sense that they are repeatable, always ensuring the same result. Whilst we can experience a relatively truthful simulation or experience in the IDE, the pure,

natural phenomenon can only ever be observed in reality, if our perceptual system allows it.

5.3.2.8. Experience: Embodiment or Disembodiment?

Following Pallasmaa (2005), who referred to architecture and the body as the loci for perception, a state of embodiment can only be reached in the IDE if all of the senses are addressed. I developed a concept of embodiment that goes beyond the fulldome environment itself. Both collective experience and peripheral vision are possible only in the IDE—as for example, can be observed in an astronomical simulation.⁹

5.3.2.9. Experience: Empowering the Environment or the Individual?

The IDE empowers both the environment and the individual. In the process of creation, the environment takes precedence over the individual, whilst simultaneously empowering the designer through his or her creative possibilities. The individual is empowered by the components of exploration and autonomy. Furthermore, individual viewers can immerse themselves and allow their senses to expand into the enlarged visual depth of the 360° environment. In some art works with which I have engaged, the viewer could interact individually with the content, thus empowering the user further by allowing a higher self-efficacy (see also Chapter 7).

⁹ For more information on embodiment and disembodiment in 360° environments, see subchapter 5.1.4 of Chapter 5.

5.3.2.10. Experience: A Collective or Individual Experience?

The collective experience under the cupola of an IDE is quite unique and cannot be achieved by any other medium (such as VR, AR, or WebVR). The unique quality of this experience is based on the real, physical presence of a group of individuals. Emotions and reactions can be felt collectively, which adds to the intensity of the experience. The experience is comparable to a live concert, live moderation inside a planetarium, or even cinema, transforming the experience into a real, live event.

Nevertheless, it is also an individual experience, because each individual person can assume a different viewing angle and thus in some ways experience one's own version of the story in a 360° show. The personal experiences of the viewers can result in the emergence of quite diverse individual meanings given to the same show. Although everybody sees the same programme, recipients take their own interpretations away with them.

This free explorative component sounds familiar and reminds us of Benjamin's flaneur and the kaleidoscopic journey of meaning through the Parisian passages. It can also be enabled in the 360° visual space, in which it gives the individual the freedom to employ the flaneur approach, explore freely the visual environment and hence create a personal kaleidoscopic assemblage of the content shown.

It is therefore interesting to ask whether a designer ought to make choices—for example by passing over a specific narrative—in order to reach a general

consensus among the group, or if it is in fact more important to contribute to the evolution of our singular, individual worldviews. Whilst I think it is important to reach a consensus among the group so that the emotional impact and intensity of the experience can be amplified, I would privilege the deeper involvement of the singular view over the collective. Only a deep understanding and awareness is remembered and can add to the overall knowledge concept of the individual. However, ideally I would aim for both, aiming to create an intensive and memorable experience with a collective component that can further our individual views of the world.

5.4. Immersion, Exploration, and Visual Lead

Whether we are a designer or an artist, the receiver—our audience—continues to be the most important element. It is the viewer who we need to always keep in mind when creating content for this environment. Thus, we need to remain sensitive to the needs of viewers encountering the spherical environment for the very first time. As a result of dominant viewing habits—imposed by the cinema and flat screens—as well as the (unfortunate) demise of the once popular mass medium of the panorama (see subsection 1.1.4 of Chapter 1), the audience needs to readapt to the 360° display. Additionally, audiences that enter the dome for the first time need to familiarise themselves with its spherical form and any inherent image distortions that may be present. Further to this, the seductive power of the controlled image—to which our audiences have become accustomed through the visual language of cinema—plays a crucial role. Cinematic visual language chooses very carefully an extract of the story via a

specific viewpoint and prepares it for the rectangular frame. The story is divided into separate, sequential viewpoints. The viewer simply needs to follow this lead and blend the images together. Audiences that would prefer to sit back and be guided through a story in the spherical space thus need a degree of assistance.

5.4.1. Immersion and Exploration

In my paper “The Aesthetics of Immersion in the Immersive Dome Environment (IDE): Stepping Between the Real and the Virtual Worlds for Further Self-Constitution?” (Buczek, 2011),¹⁰ I stated that the exploration process is maximally enfolded inside the medium of the IDE compared to the cinematic experience. My findings are based on an analysis of how the experience of immersion can be described, asking “[w]hat exactly immersion is and how it should be defined in both the technological and psychological way” (Buczek, 2011, p. 328). I was interested in how “immersion” as an *umbrella term* (Hochscherf et al., 2011) can be broken down into more specific elements.

It seemed to me that the explorative characteristic—first mentioned by Bauer (2011)—marks the primary difference between cinema and the IDE (Buczek, 2011). The embracing three-dimensional space of the IDE provides the recipient with a new autonomy of perception—the viewer can take up one’s own, individual looking position, moving the head to every side until the full spherical image has been encompassed, or choose instead to focus on a single direction in order to deepen the experience and enjoy the medium’s full embracing effect. The flat

¹⁰ The full paper is included in the Appendix of this dissertation.

screen of a TV screen does not offer an explorative journey for the eye because of its rectangular frame—it merely provides a narrow view into something. Hence, the TV screen is a very controlled way of choosing the exact perspective for the recipient; to see within exactly the frame chosen by the film maker. This limitation and its effects are accurately described by Franz Kafka (1954 in Comment, 1999), who compared the Kaiserpanorama with a moving image in his “Journal of a Voyage to Friedland and Reichenberg”: “The images are more lifelike than in the cinema because, as in reality, they allow the gaze to linger. In the cinema the objects shown move awkwardly; it strikes me that the immobility of the gaze is more important” (p.257, cited in Comment, 1999).¹¹

Once the mode of perception within the IDE has been described, the question then arises of how—and if—an immersive impact can be induced. The IDE derives its immersive character from its spherical shape, and therefore the creation of a sense of immersion by preparing sequentially (via camera work) a deeper corridor into the scene and its actors—as in the cinematic process—is not needed. In fact, the immersive function of the IDE is not easily lost, because as soon as an environment appears around you and the perspective of the image space is logical and adaptable, the viewer feels present within that visual place. Factors that may compromise this immersive capability are movements that are too quick; a still image that remains present for too long; or distortions of the image. However, boredom on the part of the viewer is perhaps the most important factor and is more difficult to avoid, compromising many 360°

¹¹ The immobile gaze will be compared to different media formats and elaborated further in Chapter 7.

productions on the market today. Avoiding boredom as well as a disconnection between the viewers and the content is far more challenging than might initially appear (see also the taxonomies described in subsection 6.3).

5.4.2. Visual Lead and Orientation

In “The Aesthetics of Immersion in the Immersive Dome Environment (IDE)” (Buczek, 2011), I also addressed the aspect of exploration and its potential challenges, such as an excess of visual input in the spherical space, making it difficult to fully grasp the content in the given timeframe and thus challenging the viewer’s ability to orientate his- or herself in relation to the narrative thread running through every scene—challenges that can cause the overall show to be overwhelming. The paper closed by asking how the exploration process can be facilitated without losing the intensity of the immersive experience by establishing a careful visual lead through the use of light, brightness, shadow, contrast, form, colours, perspectives, and specific subtle movements for the eye to follow. The examples presented in Figure 5.16 to Figure 5.19 demonstrate my use of spherical grids, camera movement, and perspective, all intended to guide the eye of the viewer inside the 360° visual space.

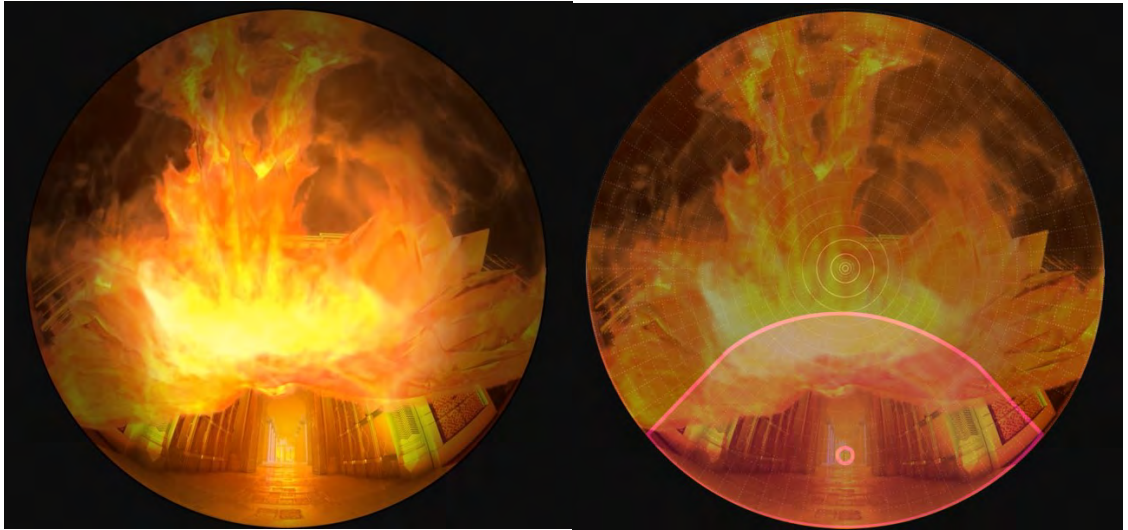


Figure 5.16. "Dream to Fly," Persia Scene, Isabella Beyer © Copernicus Science Centre, 2013.

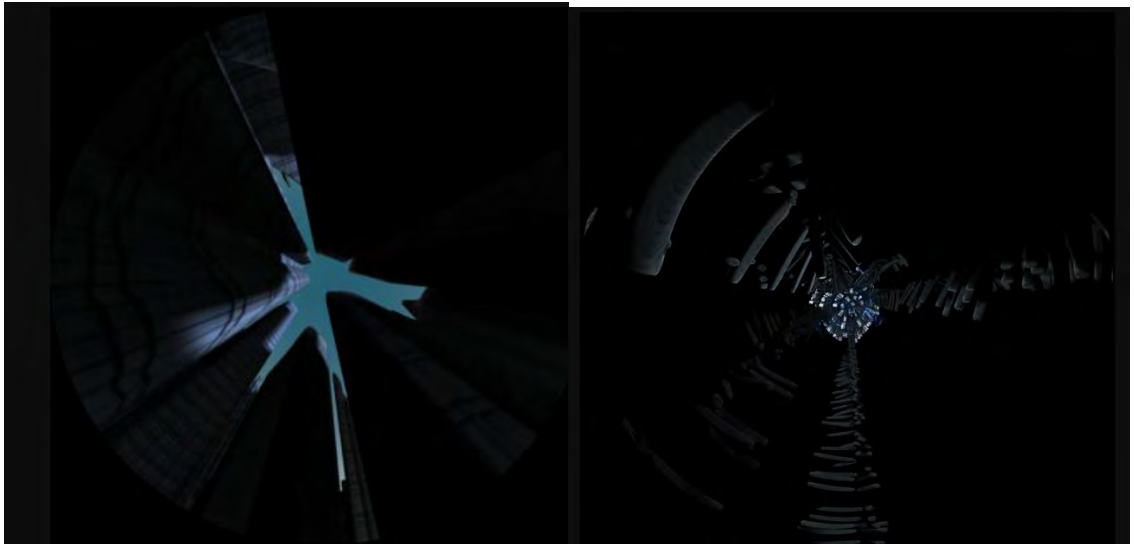


Figure 5.17. "Urban Vision," Isabella Beyer, 2007.

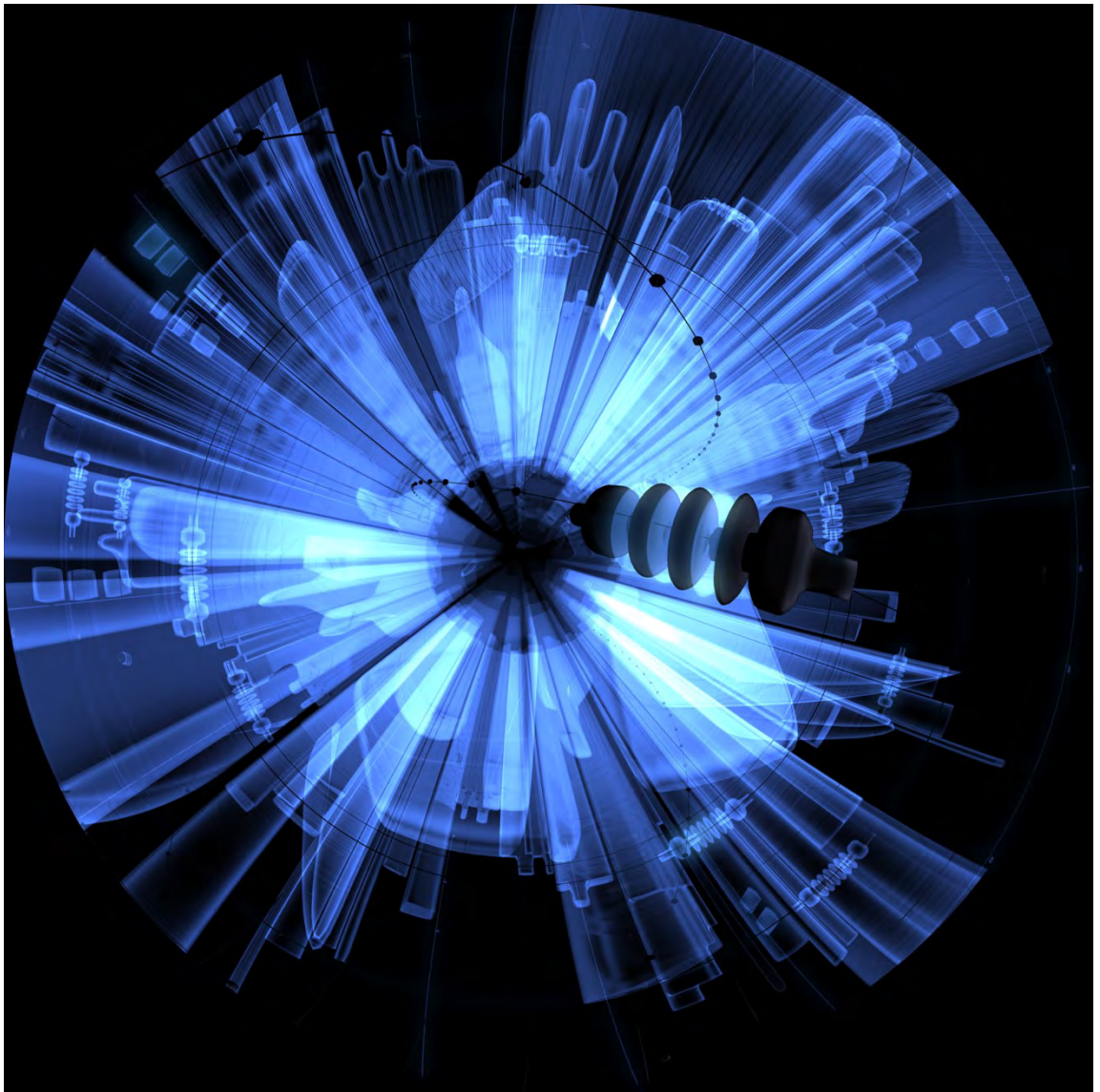


Figure 5.18. "Urban Vision," Isabella Beyer, 2007.

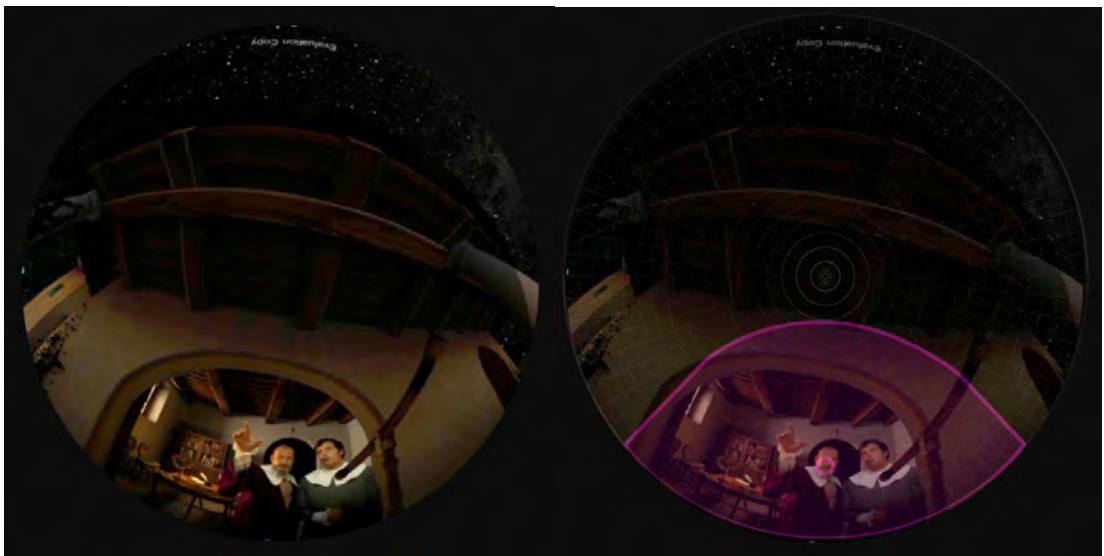


Figure 5.19. "Touching the Edge of the Universe," Isabella Beyer, 2009.

The visual design of forms, architectural spaces, and camera movements can all help to successfully orientate the viewer. However, the issue is how to avoid boredom. Our perception system is excellent at extracting meaning from a given environment, and it is also extremely good (and fast) at re-orientating itself. As Andy Clark (2008) puts it in his analysis of informational self-structuring: "The embodied agent is empowered to use active sensing and perceptual coupling in ways that simplify neural problem solving by making the most of environmental opportunities and information freely available in the optic array" (p. 17). In addition, the IDE offers a rich optical field of information for its viewers, who will deal with this information on the basis of previous experience. Each time we encounter a new environment, for example, our perceptual system copies an image of the surroundings into our inner imagination and stores it. Therefore, we do not need to turn around when standing in a room, because our perceptual system has already constructed the back of the room for us—we know exactly where we are located and what is around us, even without seeing it. Our perceptual system is trained to orientate itself very quickly. Thus, in the IDE, if the audience is exposed to a still image for too long, they can start to feel uncomfortable, quite possibly assuming something is broken.

Therefore, in order not to induce boredom in the audience or disconnect them from the content, designers of 360° environments should always seek to surprise viewers with unforeseen metaphors or transitions from one scene (or object) to another. In view of the foregoing, the important design questions here are: firstly, how to avoid boring abstractions; and secondly how to build relations, transitions, and passages between the shown content on the one

hand, and the viewer's body and local experiences on the other (see also Chapter 2).

5.5. Design Techniques for the IDE

5.5.1. No Frame, No Horizon Line, and No Dome

When creating an experience and starting to develop a scene for the IDE, it is important to keep in mind that there is no actual frame—as in the cinematic language—nor is there a horizon line or a limitation by the dome inner canvas. We create an environment without any restrictions for the viewer. Then we place or move the viewer through this environment, as illustrated in Figure 5.20. Only when the environment and camera path are established can the designer slowly make any necessary detailed adjustments to the shooting angle, arranging the lens and compensating for any distortion before rendering the first preview.

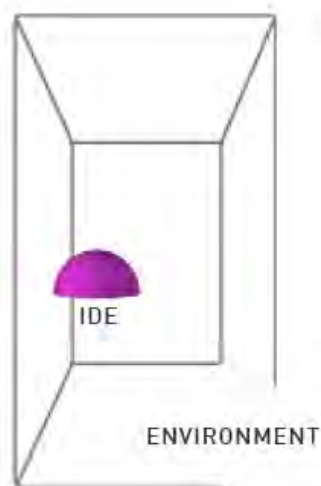


Figure 5.20. IDE and environment. Sketch by Isabella Beyer, 2018.

5.5.2. The Stereoscopic Instrument

Although stereoscopy has a long history, starting with the Kaiserpanorama in 19th-century Vienna, an in-depth analysis of the genesis of stereoscopy lies beyond the scope of this section. Stereoscopy's main function is to add depth to a two-dimensional image by presenting two different images—one for each eye. This is the basic function of our perceptual system: in everyday vision, we make sense of two images, each from a slightly different angle. Our brain puts these two images together and, in doing so, efficiently calculates the distance to the objects we are looking at. In a similar way, stereoscopy uses this same process to add additional depth to the created scene. However, this also comes with some limitations—for example, the overall perspective distortion of the image stays the same and most importantly, the viewing angle of the viewer has to be controlled in order to see the depth information properly. The images themselves are, however, still 2D and this represents the main difference between stereoscopy and holography, which also deals with three-dimensional objects, but instead reproduces them through a three-dimensional projection system, rather than via a two-dimensional image.

Nevertheless, the experience in the IDE can be quite convincing for the viewer. Indeed, in the dome at the Visualization Center C in Norrköping, I have witnessed audience members actually stand up in order to touch the objects that appeared to be in the middle of the dome. Although holography cannot be used (as yet) within the dome environment, stereoscopy provides a valuable provisional technique. I often have discussions with students as well as other professionals

regarding the use of stereoscopy in the fulldome environment, and opinions vary significantly. Some are disturbed by the limited viewpoint and reduced peripheral view—due mainly to the viewing angle of polarised or shutter goggles inside the dome. Others—myself included—see the use of this provisional medium as a valuable opportunity to work on, and optimise, the creation process, using this additional layer that at some point in the future might be adapted to a high-end holographic system.

5.5.3. The IDE used as a Camera Instrument

Through its ability to surround the viewer with visual content, the IDE has a direct effect on our perception. As my colleague Dan Neafus, the Director of the Denver Planetarium, related in a presentation he gave with me at the Fulldome Fest in Jena (Neafus & Buczek, 2011) conference, the camera is the viewer, since the 360° camera sees exactly the same what the viewer is seeing. I would like to take this idea even further, arguing that the viewer is the camera, and therefore the IDE's surroundings as well as its movements, since the IDE displays exact the camera movement.

The IDE—which reproduces the movement of the spherical camera as controlled by the designer—thus needs to be used very carefully, not least because the image is magnified many times over the available preview size available to the designer during the recording process. When displayed on the surface of the IDE—possibly at resolutions up to 4 or 8K—the image becomes magnified many

times over. This magnification is limited only by the IDE's size, which depends on the cupola ceiling and can vary from 9 up to 30 m in diameter.¹²

Since the content in the IDE is the viewer—or at the very least, the eyes of the viewer—and most of the IDE's content is being prepared with a camera—either a physical camera or the virtual camera of a 3D animation program—it is important to both analyse and appreciate the difference between the perception of the human eye and that of the camera lens. Contrary to the human eye, which can only focus on one specific object at a time—also known as foveal seeing—the lens of the camera can zoom in on objects and the camera can move towards them whilst simultaneously filling the whole peripheral field and visual surroundings in 360°. Therefore, the fish-eye camera and its movements, as well as the precision of its lens, are particularly important considerations when preparing content for the IDE. The specific camera functions are considered below.

A mathematical camera in three-dimensional software is able to:

1. create a greater depth of field;
2. use depth of field by making one object sharp and blurring the environment, dependent on the distance of the object;
3. rotate, revealing more of the surroundings;

¹² The Mediendom at the University of Applied Sciences in Kiel has a diameter of nine meters, whereas the planetarium (2012) in the Nagoya City Science Museum in Japan is 35 meters in diameter.

4. have a tipping movement, revealing more of the area beneath the camera;
5. distort, and therefore include, more visual information of the bottom area on the same hemispherical surface.

IDE content is obviously not only dependent on the camera work, but also on the wider environment created. The success of the programme depends on the visual complexity of the storyworld created, especially on

1. how much detail it has—as in textural resolution, and in the modelled objects;
2. how many scale levels—from the micro to the macro—are created.

How can the camera help the orientation of the viewer when the created environment is so complex that it comprises many different layers, from the micro to the macro? One technique—the use of transitions—can be employed, for example as follows:

1. a rotating spiral movement through different scale levels of a complex 3D world consisting of true and accurate proportions, as seen through a microscope;
2. whilst rotating and moving down to the next scale level, the 360° rotational viewpoint can be used to enable comparison so that different objects of different scales can be seen next to each other for a brief moment, as I described in the paper “Le Passage: An Archaeology of Spatial Transitions” (Beyer, 2014).

5.5.4. The Unchained Camera

The German term “*entfesselte Kamera*” [“unchained camera”] describes a specific camera technique from the 1920s. It was an innovation designed by F. W. Murnau that allowed filmmakers to get shots from cameras in motion, enabling them to use panning shots, tracking shots, tilts, crane shots, and so on—thus giving the operator more freedom and enabling a form of zoom by approaching the subject (Prümm, 2004).

We used this technique in combination with the Red One camera, and a specific self-made adapter with a fish-eye objective for the shoot of Galilei Galileo in the show “Touching the Edge of the Universe” (2008) for the European Space Agency (ESA), as illustrated below in Figure 5.21 to Figure 5.23.



Figure 5.21. Photo of our shoot inside Theater Kiel. Photograph by Isabella Beyer, 2008.

In the 3D Galileo scene, the camera moves into Galileo's study room. Via the three-dimensional arrangement and camera movements, the audience is relocated. The audience becomes immersed in the scene and a pure spatial experience is created. With the help of a camera crane, the actors could be relocated between a virtual balcony, 360° scenery, and Galileo's study room. Additionally, the camera could come very close to the hand of Galileo, which was appropriately distorted by the fish-eye of the camera. This looked especially impressive in the final IDE presentation.



Figure 5.22. Photograph of our shoot inside Theater Kiel, "green screen." Photography by Isabella Beyer, 2008.



Figure 5.23. Final composited image, including the real actors and the 3D environment. 360° scenery and animation by Isabella Beyer, 2008.

Figure 5.22 and Figure 5.23 illustrate how the green screen and camera-based fish-eye shootings were blended with the virtual environment. This was not an easy process, because the physical fish-eye camera had a slightly different spherical distortion than the mathematical fish-eye camera of the 3D software program. Therefore, many adaptations and manipulations (made with the help of an additional tracking camera) had to be performed manually.

5.6. Critical Discussion of the IDE

This section intends to look at the IDE from a critical point of view, as the medium—in common with many other—also has its limitations. Firstly, I will focus on the issue of autonomy. Autonomy and self-efficacy are vital in order to make the viewer feel present in an environment, and able to act within it. The digital planetarium requires first that the audience *wants* to be in this environment, and does not feel forced to occupy the presented places for too

long. In the panorama environment visitors choose how much time they want to spend inside the presented location, which can be classified as a gaining of autonomy. When sitting in a digital planetarium, however, the viewer is forced to remain seated and stay in the visual environment that is presented to him or her over a given timeframe.

5.6.1. Slow Motion: Shut Down Effect

I wonder if the moving image of the fulldome theatre—especially when presented too fast, due, for example, to an overly rapid camera movement—does not lose its value, potentially causing the displayed environment to lose its validity completely. Only through the use of slow and considered movement can the 360° visual environment realise its full intensity and allow the gaze to freely explore the presentation.

There exist examples of astronomically overloaded planetarium programmes, which repeatedly overwhelm their visitors with abstract information and abstract images, giving them no chance to relate to the input in any meaningful way. It is no surprise that the cognitive capabilities of these programmes—with their viewers struggling to match the incoming information with known, real experiences—fail, causing their viewers' brains to shut down, resulting, more often than not, in a sleeping audience. Whilst working at different planetariums as a 3D science visualiser, I have often observed how overwhelmed visitors can be when exiting a show. When talking with them, I often discover that they were simply unable to grasp what they saw.

If poorly executed planetarium programmes grow in number, and developments within VR open new channels for guided universe tours—perhaps even through group experiences—might this pose a real threat to the digital planetarium? If so, in which directions should the digital planetarium develop in order to continue to attract audiences? The subject of attracting audiences is further discussed in the final chapter of this dissertation.

5.6.2. Patterns of Consumption and the Right Content

Assuming the audiences visiting the IDE would like to be entertained whilst laying back and being “sprinkled” with moving images, as they have become accustomed via their TV or YouTube channels, would the audience want to be forced to move their gaze around the dome’s surface? Imagine a person would be able to watch his or her usual daily content inside a 360° holographic projection in their own living room, with their partner sitting next to them watching the same content. Would the audience watch journeys through the universe, or would they want to be guided by a knowledgeable, real person inside a live-event taking place at a planetarium? How easy would it be to change the habitual immobile gaze into a mobile gaze whilst watching 360° content in one’s own living room?

Perhaps it would change quite fast, as we are used to looking around a full 360°. The answer really all depends on familiarising ourselves with specific consuming patterns. The utilisation of such viewing habits will depend largely on

the content. Many would abstain from watching the daily news reporting a new terrorist attack in 360° due to its unbearable intensity, but a documentary dealing with a specific theme of interest, such as historical architecture, might present an attractive option. As the recent popularity of Pokémon GO illustrates, many users like to be immersed in gaming environments.¹³ Locations that might have been forgotten in an urban space might be revalued when blended with virtual models, perhaps even causing the urban citizen to use different navigation habits through their city. Through technological changes, patterns of behaviour and consumption will continue to change rapidly.

5.6.3. Case Study: Lift-Off

The IDE and its taxonomies teach us new ways of seeing, experiencing, and understanding, altering our perspective on the world around us, as well as our identification with it. In doing so, visualisation practices help us to expand our self-constitution—the relation of our body to nature, to local, global, or cosmological space. The best example regarding a perspective shift amongst my own recent productions is the “lift-off experience,” produced with a 360° rig and a drone whilst filming a wind turbine.

The following two images compare the 360° viewing experience of a lift-off experience in the year 1900 (Figure 5.24) and the year 2017 (Figure 5.25). The

¹³ Pokémon GO is an augmented reality app for iOS and Android smart phones that was realised in 2016 [see <https://www.pokemongo.com/en-gb/>].

original historical concept has been described in subsection 1.1.5 of Chapter 1, describing the lift-off with the Cinéorama during the 19th century.



Figure 5.24. Balloon ascent via the Cinéorama. General View of the Interior. Raoul Grimoin-Sanson, 1900.
¹⁴

Figure 5.25. Drone ascent at a wind turbine on the oculus rift. Production and photograph by Isabella Beyer, 2017.

In 2017, I had the opportunity to produce a lift-off experience for the company EnBW Energie Baden-Württemberg AG, using this historical concept with new technology. For the shooting, a camera rig of seven Go Pro cameras was used, as well as a drone. I directed the camera team to start with a fully still image of the bottom of the wind turbine at eye level, as the rectangular image below demonstrates (Figure 5.26).

¹⁴ Retrieved May 13, 2016, from <https://en.wikipedia.org/wiki/Cin%C3%A9orama>.

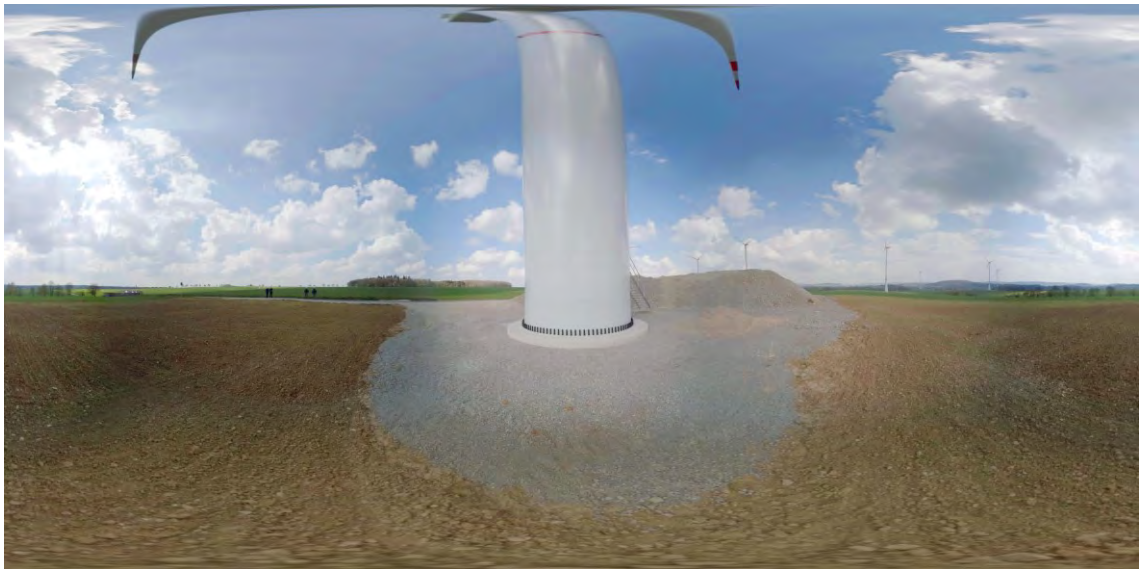


Figure 5.26. The rectangular image that can be wrapped around a spherical image, illustrating the starting point of the lift-off experience at the bottom of the wind turbine. X by Isabella Beyer, 2017.

Then, from the still image, slowly the movement of an ascent evolved, lifting the audience later in the 360° image slowly up along the wind turbine, giving them the opportunity to look in every direction during the flight—around the full sphere, up, or even down to the ground, or around the beautiful landscape.



Figure 5.27. The rectangular image illustrating the end point of the lift-off experience at the top of the wind turbine, overseeing the wind farm. X by Isabella Beyer, 2017.

The ascent flight ended slightly above the top of the wind turbine in order to gain an overview of the wind farm (Figure 5.27). The final flight could then be watched using the Oculus VR Gear, however, the viewers had to be seated in order not to be overwhelmed by the height and overall flight experience. The wind turbine lift-off experience was well appreciated and is still being shown on frequent road shows and exhibitions today. The 360° space inside the VR goggles functioned as a flying vehicle, allowing the viewers to freely explore the 360° space during this flying passage.

5.6.4. Case Study: The Sky Disc of Nebra

As a more tangible example of spatial data visualisation, I now turn to my own work “Himmelsscheibe von Nebra” [Sky Disc of Nebra] (Buczek, 2007). I frequently use data visualisations in my own productions, trying to integrate data into spatial 3D landscapes whilst keeping proportion and scale realistic. These data types can vary from Keyhole Markup Language (KML) files or photo geometric scans, to volumetric models and large point clouds that need to be adapted in order to make them useable by the software whilst taking care not to lose too much important detail of the surface—in this case, the surface of the original Sky Disc of Nebra (see also subsection 1.3.3 of Chapter 1).

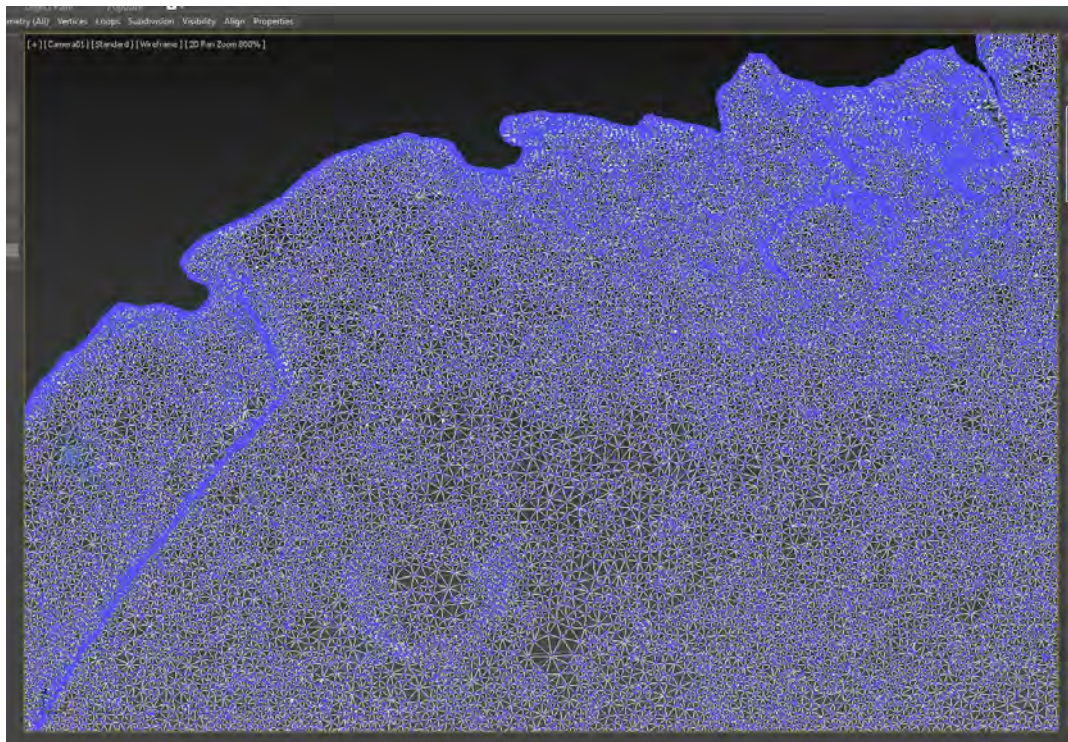


Figure 5.28. Point cloud of the final result. Sky Disc of Nebra, Bob Weber, 2008 (with friendly permission of the artist).

This effort makes particular sense when archaeological objects with a specific prehistoric appearance are being scanned and visualised—such as the Sky Disc of Nebra. The image presented in Figure 5.28 shows a 3d geometric scan of the original Sky Disc, transformed into a polygon mesh in the 3D software 3DS Max. On this foundation an additional photo scan of the surface was used as a texture, resulting in a very authentic digital 3D model of the Sky Disc and revealing much more detail and surface information than, for example, a 2D photograph (see Figure 5.29).

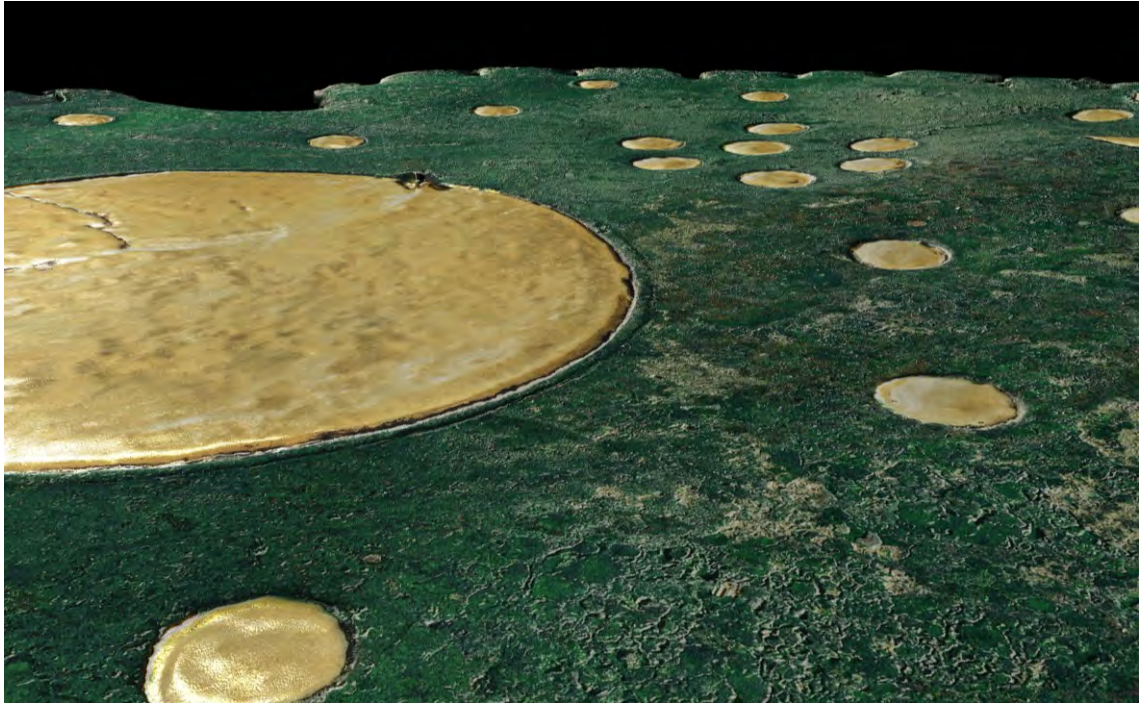


Figure 5.29. Point Cloud of the final result. Sky Disc of Nebra, Bob Weber, 2008.

The Sky Disc of Nebra proves that the virtualised model can have quite an intensive *aura* (Boehme, 2001) whilst revealing complex information. Not only is a virtual 3D model capable of creating an aura around it, but virtual models can also create also emotional space.

5.6.5. Aura, Space, and Direct Feeling in the IDE

The following discussion follows the presumption that virtual space can be regarded as fully able to create an atmosphere, and eventually feelings—as a physical space is. A feeling can be induced and modelled by atmosphere, space, and intensity. Purity vanishes in order to make space for hybrid media interpretations and permanent metamorphoses—both of the users, and of the technological environments we are creating and using. These metamorphoses are based on numerous set variables and algorithms—manually through the user at one end, and artificially through the prearranged software set-ups at the

other. The resulting spaces are directly caused and created by virtual variables and algorithms. The question is how the highest quality of feeling can be achieved inside these destabilised spaces. The following quote illustrates that the physical, felt emotion between the perceiver and the perceived is key to the production of emotion:

The taste of the apple . . . lies in the contact of the fruit with the palate, not in the fruit itself; in a similar way . . . poetry lies in the meeting of poem and reader, not in the lines of symbols printed on the pages of a book. What is essential is the aesthetic act, the thrill, the almost physical emotion that comes with each reading. (Jorge Luis Borges as cited in Thurell, 1989, p. 2)

Additionally, Gernot Böhme (2006) postulates that aesthetically designed objects possess properties that make an atmosphere arise inside the encounter with a perceiving subject. As an example, he chooses architecture, which through its exterior and interior design guides the attention. Architecture lives from the quality of the moods it can create in space. These spaces, therefore, engender strong emotional reactions and result in highly immersive experiences (Böhme, 2006). Things can speak (Daston, 2008) and spaces can and want to speak

(Bieger, 2007, p. 19). Spaces as well as things have an “aura,” and therefore an atmosphere can be generated between object and subject (Böhme, 2001).

Böhme clarifies further that the fundamental condition for simultaneous inner and outer experience can only be activated, centred around, and focussed inside the viewer’s own body (Böhme, 2001, p. 31).

Inside the IDE, an atmosphere is created by the projection itself, but it can also be reinforced. In the artwork “Liminal Spaces,” SAT, Montreal, 2016 (see Figure 5.15) for example, the architecture—which was displayed on the dome of the Satosphere—had an atmosphere, but it was amplified through a performance by additional groups of actresses inside the dome as well as other physical objects, such as small containers that were pushed around by the actresses and could simultaneously be observed in the projection. This way the atmosphere of the digital projection could be connected to, and enforced by, physical, haptic enactment under the dome, right next to the audience.

The intensity of impressions and feelings is essential for the quality of perception: it makes events and things relevant, emphasizing them and making them memorable. Therefore, the artwork described above tries to awaken strong, intensive emotions through sound, colour, and movement in order to persist in memory. Feeling can bring things, experiences, and persons into memory (Lehnert, 2011, p. 16, p. 17). This is also supported by Harald Welzer (2005), who states that cognitive processes, and also learning processes function much better if they are supported by emotions and memories which are enabled through emotional occupations. In that context feelings are the generators of sense and meaning (Welzer, 2005). Therefore, emotional design—as coined by Don Norman (2004a)—plays a significant role in the design process. Artworks do not have to explain the world; it is fully sufficient for them to trigger a specific emotion in us. This emotional component can then stay with us

throughout our lives. Such emotional experiences can be enabled in the IDE in various ways since the IDE can develop its own aura and visual space around us.

5.7. Conclusion: The IDE's Taxonomy

This chapter illustrated different techniques for the designer or artist to use when creating Immersive Dome Environments, as well as providing an analysis of its taxonomies and functions as a visualisation instrument. Its potential in relation to the imagining and understanding process was evaluated through concepts such as stereoscopy, the unleashed camera, or the kaleidoscopic passage. Furthermore, I demonstrated that taxonomies, such as the spherical taxonomy, could train and encourage the designer not to use only foveal vision. Instead, all of the senses can be engaged, including the peripheral vision. Peripheral perception is more emotionally intense and its use ensures that the presented and experienced knowledge will be retained for much longer. The peripheral vision in particular can expand the viewing angle of a scientist who is conditioned to look, for instance, through his microscope at very small and limited areas. The peripheral vision in the IDE can help to expand his viewing conditions and enable an overview of his field of study, especially if the path and overview are incorporated, ensuring a harmonious connection and interrelation between these two distinct views.

Furthermore, the 360 ° taxonomy favours passage construction by influencing the sense of balance, triggering the body's conditions directly. Thus, the feeling of floating, flying, or swimming transforms the IDE into a vehicle. If the passage

touches our senses and feelings through peripheral vision, this can have a direct, intense effect, enabling embodiment: a unity between our minds and our bodies by experiencing the same visual environment. Such an experience challenges the mind to stay inside the experience and inside the body whilst continuing to perceive and make sense of it.

The IDE should remain an important tool with which to create spaces and passages for the mind and not the other way around—creating spaces and passages to which the mind has to adapt. Here, Don Norman's (2004b) concept on things that make us smart is informative: "The power of the unaided mind is greatly exaggerated. It is 'things' that make us smart, the cognitive artefacts that allow human beings to overcome the limitations of human memory and conscious reasoning" (internet page). Norman (2004b) reasons that the most important tools of all are cognitive artefacts, which have made human beings smart and had the largest impact on civilisation—such as writing, notational systems, objects of travel, and information technology. The IDE allows us to travel virtually through various data landscapes, from the micro to the macro, and has the imbedded characteristics of a vehicle and passage through 360° camera movement. Therefore, the IDE too can be classified as a cognitive artefact that can aid the mind to travel beyond its existing knowledge horizon.

6. Future 360° Concepts in IDE, VR, AR, and MR

After evaluating the IDE and its taxonomy in Chapter 5, this chapter examines the contextual environment surrounding the IDE today. As stated in the introduction to this dissertation, the IDE is not disconnected from its broader contemporary cultural and media context, but is instead frequently woven into the nets and collaborations of today's various rapidly developing media contents and formats, such as Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) via their numerous technologies and applications. The IDE medium offers a productive space in which these media formats can meet, co-exist, or blend together, as for example inside the Satosphere (SAT) in Montreal, Canada. The Satosphere forms a space of passages between differing content, such as interactive components, performances, multi-user co-creation spaces, or the streaming and recording of VR spherical content that is altered in real-time within the dome. Instead of relying on a single visual language, the envisioned experience is dependent upon different narrative formats, from the past (i.e. cinema and film, theatre, video games) as well as from the future (i.e. new interactive and performative applications). The interplay of these various formats creates an interesting narrative mix inside the IDE, where they converge and form new applications.

Yet, are these applications more valuable than the traditional fulldome storytelling inside the planetarium? Should the IDE adapt to new interactive applications, such as the field of VR, or should VR learn from the IDE instead, learning how to tell stories and use the spherical space? In this chapter I will investigate, not only how all these formats can meet inside the IDE, but also how the IDE's spherical passage concept can be expanded to further 360° media formats such as VR, AR, and MR. In that way the blending of media formats and important synergies can be enabled, giving the experience a lasting impact. For this purpose the transmedia project "Superhelden der Ozeane" ("Superheroes of the Deep Sea," 2017) has been elaborated upon as a case study in order to reveal its potential in storytelling and precisely in the epistemic concept of scale comparison through media blending.

6.1. Transmedia Storytelling: A Definition

The development of technology and emerging new media tools are revealed in the media convergences that occur via smart TVs, online streaming platforms, and smart phones—both in terms of technology and content. They alter how stories are told and shape new content, such as web storytelling, blog fiction (Egan, 2012), and transmedia storytelling. The development of the 360° narrative, referred to as 360° storytelling, could evolve further to transmedia storytelling as well as involving further media formats. Henry Jenkins (2008) coined the term transmedia storytelling and explains that "a transmedia story unfolds across multiple media platforms, with each new text making a

distinctive and valuable contribution to the whole" (pp. 95–96). Jenkins (2008) also understands transmedia as the core of convergence media culture in the context of his work (p. 129). The transmedia narrative technique involves one, all-embracing story, which can be a whole narrative universe or a specific moment in time. This story is told through several media channels that all lead back to the same story universe. With each storyline and corresponding media channel another target audience can be reached.

As an example of how transmedia storytelling could enhance experiences inside the IDE, the show "Dream to Fly" (Buczek, 2013), for example, could have included the possibility of testing the different flight objects inside a HTC Vive Application, either live at the event, or afterwards at home, bringing the experience of flying to another, more personal level. Additionally, some scenes could have been investigated online through an interactive 360° video on YouTube, and the main innovators of flying machines from this 360° movie could be met on Facebook, allowing the audience to gain more knowledge of their former lives and emotional encounters whilst working on their flying innovations. A VR game could have introduced the players to physics and engineering whilst building their own flying object with the tools available at that time. Subsequently, the player could order a three-dimensional model of his or her favourite flying machine produced via 3D printing. These are all examples of how transmedia storytelling could enhance the experience of IDE audiences, making IDE shows such as "Dream to Fly" more dramatic and accessible.

In the following subsection, I will describe in detail how contemporary narrative concepts are being told, either as part of a transmedia 360° storytelling project, by being a passage in itself, or by sharing passage components. In doing so, I explore how these methods might be used and experienced in the future inside the IDE.

6.2. IDE vs. VR, AR, and MR

In order to explore the potential of each medium for transmedia storytelling and compare the spatial experience inside these media to the IDE, I tested and analysed the following media formats, including VR, AR, and MR via the different goggles illustrated underneath (Figure 6.1). With the understanding that technology does change the narrative and the concepts that are being told in mind, each device and its functions were considered.



Figure 6.1. Own image composition, Isabella Beyer, 2017.¹

¹ Goggles have been retrieved from their individual websites.

6.2.1. A Comparison: The IDE vs. VR

Inside the IDE, the gaze is allowed to linger in any direction of the 360° periphery; it is free and mobile. In the case of VR goggles, the gaze is interactively encouraged to move around a full spherical image through the constraint of a limited view, framed by the borders of the goggles. Once the head and therefore the gaze moves the cognitive apparatus, the viewer starts to construct the full spherical environment, building his or her own model of it. Once established, the perception can be focused on activities of interest and if desired, allowed to linger on them. The viewer also gains a sense of control—a very different experience to the conditioned viewing enabled by a rectangular frame. The user is able to control the segments of vision that he or she wants to focus on. Paradoxically, the user simultaneously loses peripheral perception—often without noticing, because, as many of my usability observations revealed, the experience of gaze control prevails. Yet, it is impossible to see all of the 360° environment. By moving and therefore changing the position of the head, only a single section can be viewed at any given time. This effect becomes evident when viewers watch fast changing environments without having the possibility to see what is happening behind them; the viewers have to constantly turn their heads around in order to look behind and thus gain a sense of security.

This VR experience quite differs from the online capabilities of 360° video, where the viewer can navigate inside a video window to gain the full 360° view. It is not dependant on our natural head movement, and therefore the gaze stays

immobile. We adopt a frontal view, looking directly at a rectangular framed video on our web browser. Only tactile interaction allows us to move the image space to other areas that lay outside the frame. Depending on the device—mobile phone, tablet, or a flatscreen TV—the frame can vary in size. The frontal, immobile gaze persists, in much the same way as in the cinematic setting.

It is interesting how VR—or more precisely, producing content for VR and its full 360° sphere—changes one's perspective of the IDE. The dome appears to the designer as an incomplete half sphere in comparison to VR. Thus, the main distinction between VR and the IDE is the availability of the full visual sphere instead of a cupola. The VR experience results in a very individual experience, as viewers are on their own inside a virtual environment. This is further effected by the closeness of the environment through the goggles, and the enhanced "*selbstwirksamkeit*" ("self-efficacy") through the interactive component of, for instance, a HTV Vive application that adds to the experience.

In the past, there have been many envisioned VR concepts and prophecies that illustrate quite well how people imagined the future and what kind of fears they had—or may indeed still have—regarding the concept of VR. Some of the strongest, most alarmist suggestions worry that "VR challenges the concept of reality," or even that "VR will someday replace reality" (Ryan, 2001, p. 1). VR could certainly challenge the concept of reality—or at least our perception of it—for example if the VR application shows our local environment from different perspectives, such as those of birds or flies, showing us how they perceive their

environment. This was realised for instance with the project “In the Eyes of the Animal,” produced by Marshmallow Laser Feast (MLF) and presented at the AND Festival, September 18–20, 2015, Grizedale Forest, Lake District, UK.² The artists were interested to use new immersive technology to give visitors fresh sensory perspectives. Another approach could be to make macro and micro worlds experienceable with the possibility to scale oneself up or down inside an interactive VR application. This could be further refined by expanding the passage concept to teleporting passages in scale with spiral techniques.³ A new “Powers of Ten” passage experience could be created inside VR, embodying the whole 360° sphere of a VR application for scale comparison. A whole range of spatial scale exploration tours could be made available through the VR experience.

Games or applications that use, for example, the HTC Vive with infrared sensors and controllers, allow the user to interact and move through a virtual space. For example, in an urban environment, the user can physically move in a square of 4 by 4 m, which is quite confined. In order to discover more of the given environment, the user can teleport him- or herself to more distant places in the same storyworld, such as a mountain from which the user can look down, or the

² More information on the immersive VR experience can be found online:

<https://mobile.digitalartsonline.co.uk/news/interactive-design/vr-project-experience-grizedale-forest/> (last accessed April 23, 2018).

³ Please see Chapter 2 on the IDE’s taxonomy for more information on passage and spiral techniques inside a 360° spherical environment.

next street intersection to move deeper into a given cityscape. These teleporting moments can also be regarded as passages, giving the user the feeling of moving, navigating, and sometimes even flying through space whilst maintaining the user's sense of orientation. The use of teleporting in VR is regarded as resulting in a less natural experience, since humans are not used to teleporting experiences in the physical world. The sudden change of locations experienced whilst using teleports—as often seen in fantasy or science fiction movies—was considered to be unreasonable in VR because of the orientation loss and motion sickness.

However, new research conducted at the University of California suggests otherwise. Scientists Lindsay K. Vass et al. (2016) recorded hippocampal EEG activity in patients undergoing seizure monitoring whilst they explored a virtual environment containing teleports. Without really showing the traversing of space, the participants could very well re-orientate themselves when being teleported to different locations. The scientists proved that navigation can be sustained, even when visual cues are removed and the only available spatial information is internally generated from memory (Vass et al., 2016). The human being is thus perfectly conditioned for teleporting experiences. Another sign is the success of the video game "Portal" by Valve Corporation (2007), which shows how willing the players of this game are to experience teleportation and moments of re-orientation. The teleportations occur as passages between the test chambers through which the story unfolds (Burden & Gouglas, 2012). Thus,

whilst VR might initially be treated with a sense of suspicion, our modern world seems to adapt rapidly towards its potent possibilities.

6.2.2. A Comparison: VR vs. AR and MR

AR can be experienced through different apparatus, such as the Microsoft HoloLens; mobile screens that allow one to see through the device into the physical environment via a rear-facing camera; or in the near future hopefully into true holographic displays.⁴ Although most AR applications are still in their infancy, AR appears to be quite a promising technology for the future because of its built-in integration between the physical environment and virtual objects called augments on the one hand, and through its blending approach, allowing transitional experiences and passages between the physical and the virtual even easier on the other. Sometimes the whole virtual world inside a HoloLens can be virtually mapped into the real room in the correct proportions via spatial mapping and measuring, whilst sometimes there can be only very few augments or virtual objects.

⁴ Augmented Reality can be defined as an enhanced environment as viewed on a screen or another display, produced by overlaying computer-generated images, sounds, or other data on a real-world environment. Or, even more to the point, it can be described as “an artificial environment created through the combination of real-world and computer-generated data” (Collins English Dictionary, 2017, “Augmented Reality”).

In contrast to VR, AR does not substitute the physical surroundings, but rather complements or augments it by adding further informational layers, such as 3D models, videos, text, or images. In this way, a process of augmentation—between the device and the surroundings—is enabled. It combines the physical world with the virtual, resulting in Mixed Realities (MR). Unlike VR, which only takes digital and computer-generated content as its image source, AR uses the direct physical environment as an image source in addition to digital content. The feeling of presence also differs: In VR, the user is fully immersed in virtual reality, as illustrated below in Figure 6.2. Whereas in AR, the user can still be present in the physical environment, depending on the application used. Some applications use additional information layers, and some whole game environments.

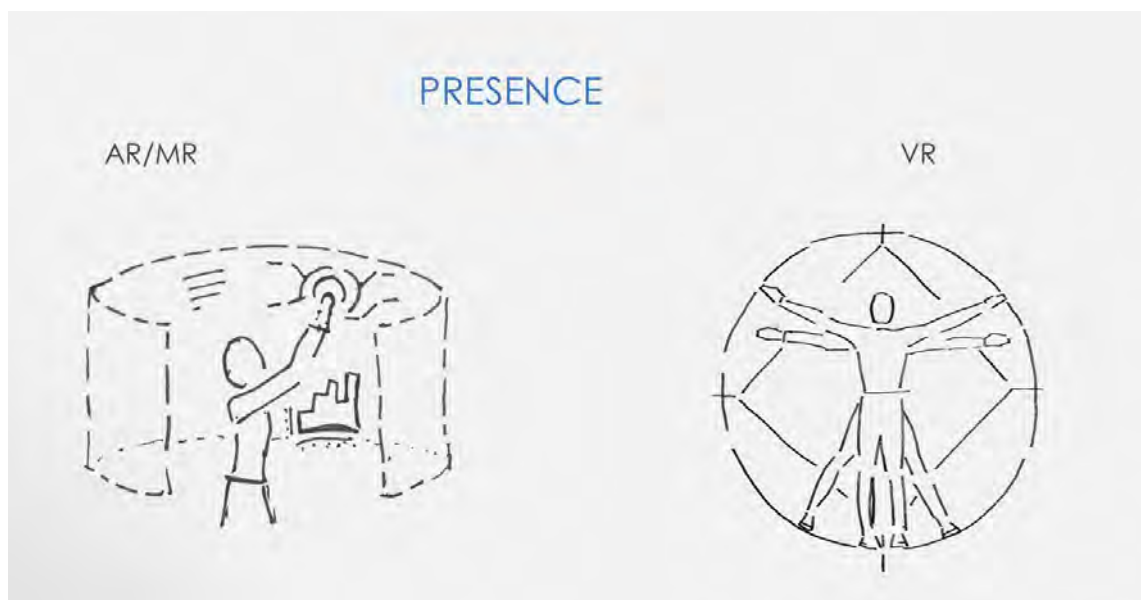


Figure 6.2. Presence comparison between AR and VR. Drawing by Isabella Beyer, 2017.

Virtual objects in AR are identified either through their interaction with the user or through the physical environment. The blending that occurs between physical

and virtual interaction is relatively tight and accurate, enabled via a depth of field camera and four further environment understanding cameras, which allow spatial scanning and accurate measurements, as well as tracking of the physical surroundings. This way, the physical surroundings can interact with virtual models and be reused inside virtual applications, for example causing virtual characters to stand accurately on real, present objects such as tables, chairs, or other furniture within the physical environment. The appearance of virtual objects is transparent and less detailed.

However, in VR (albeit dependent upon the application) the virtual objects can look very realistic and detailed—just like in the physical environment. Both VR and AR can use peripheral vision if the viewing angle of the goggles permits it. For virtual objects and characters in AR, the reference point is the user and his or her physical environment, and thus its behaviour is based on real-world properties. In VR, if interactive, the objects react to the user, whose behaviour is based on the virtual and digital environment. Therefore, virtual objects in VR behave based on virtual properties. In summary, one can say that both technologies allow passages between the real and the virtual through transitional, performative practice, yet this is achieved in quite different ways, by using information from the virtual and the physical environment differently.

6.2.3. VR, AR, MR, and the Mobile Screen: Passages through Performance and Navigation

There are other exciting concepts regarding both AR and mobile screens that bring together process, performance, and performativity in passage experiences via screen-based media. Nanna Verhoeff's (2012) research is based on mobile screens and their role in urban screen culture.⁵ She argues that urban citizens equipped with mobile screens in some ways could be considered as "postmodern" cartographers, creating space by navigating through, and interacting with, an enhanced environment; in other words, by looking on their GPS devices whilst moving and recording their own passages. However, unlike traditional cartography, which tries to be objective whilst rendering space in different scales, Verhoeff understands this practice as a subjective, flexible, and open-ended practice of personalised space-mapping. As an example, Verhoeff cites the practice of geotagging, through which geographical identification data are embedded in media such as photographs, thus producing an individual "map" by tracking the user's own movements. 360° panoramas and images of urban landscapes can be uploaded on Google Street View in order to be used via Google Earth VR. This creation practise is only possible through recent technological developments—particularly the use of smart phones as cameras, interfaces, GPS devices, and creative tools for recording and sharing on the net (Verhoeff, 2012).

⁵ Nanna Verhoeff is an Associate Professor at the Department of Media and Culture Studies at Utrecht University.

As Verhoeff (2012) points out, “these devices turn the ‘classical’ screen as flat and distanced—as well as distancing—window on to the world, into an interactive, hybrid navigation device that repositions the viewer as central within that world” (p. 137). Therefore, rather than a mere representational tool for passive consumption, the new technological possibilities could allow for a more active approach to performativity. New spaces come into existence on, and are communicated via, the net through personal, embodied experiences of space. Each individual user makes his or her own individual passage through the urban space visible on the net. Therefore, I suggest it is also a passage experience: not only are new, personal passages formed, but the practice in itself also becomes transitional—the user occupies an in-between state in which the physical, spatial experience and virtual information interweave, exchange, and in doing so, create something new.

This positive performative practice could also be used within a transmedia concept, and linked with an IDE experience in the future. For example, once audiences experience a journey in outer space inside the IDE, they could use the virtual model of the cosmos on their GPS devices and create a new, individual path, developing their own, personal journey through the universe. Indeed, in 2017 a student created an augmented reality experience in a course that I taught at the University of Applied Sciences in Karlsruhe by placing her own virtual models around the castle grounds of Karlsruhe. Each model represented a planet in the solar system and could be retrieved through scanning an image on

the ground via a mobile device. All of the planets were represented in their relative proportions and sizes. The sun and the centre of the solar system was the castle itself. Through physical movement the audience could inhabit the space of the whole model and, more importantly, they could physically experience the distance between the planets.

6.3. Case Study: “Superheroes of the Deep Sea”

Proceeding, I will illustrate how the passage concepts and creations inside the IDE that have been described throughout this thesis can be expanded to encompass further media formats, which eventually come together and meet inside the IDE in order to reach a full, all-encompassing experience. The case study “Superheroes of The Deep Sea” will be introduced in the context of sensing space, highlighting our ability to re-centre ourselves and to take responsibility for our environment. The outcome is based on an unpublished paper for the conference Balance Unbalance 2017—A Sense of Place (August 21—23, 2017), in Plymouth, UK.

6.3.1. From a “Sense of Place” to a “Sense of Planet”

The first thing that springs to mind regarding the topic “sense of place” is how balanced our imagination of local and global really is. This is true especially in the light of our present time and the growing, essential need to raise awareness of climate change and the oceans in order to take action and to concretely

change human behaviour, first within local communities, and then on a global scale.

The way in which we imagine “the local” and “the global” heavily relies on the concept of scale. As Herod (2009) states, “the idea that the world is scaled (or not) recursively shapes how we comprehend its nature. In other words, ideas about scale structure the knowledge we create about the scaled nature of world” (p. 255). The process of scaling and drawing our environment is very much ingrained in our existence, and intimately linked to the practice of localisation and self-constitution. For example, questions such as “How big am I in comparison to the world, the cosmos, the earth, or a specific continent, country, city, or street?” and, therefore, “How much of an influence can my actions, enacted here within my local environment, have upon the world?” demand answers. Through cartography and scale, we have learnt to manage our surroundings, organising space by separating and dividing the world. We got used to what Lefebvre (1991) refers to as “carving the world by scale to make it more manageable and analysable” (p. 5). These scale approaches were viewed, as coined by Lefebvre, as “space envelopes.” Lefebvre explains further that “every spatial envelope implies a barrier between inside and out” (p. 176).

Although in present-day cartography, maps have been enriched through satellite images and are more precise than ever before, in our imagination they remain fragmented. For instance, viewers would study such maps in a printed, flat format upon their arrival in a new city, trying to find their directions in relation to

their current location. Or, if the internet connection is working, they might look at navigational apps: digital maps on their flat mobile screens. These use of digital tools or being present in several different digital spaces at once can, on the contrary, splinter our spatial perception (Mersch, 2011). The earth's spherical shape or its gravitational centre are not present in either of these representations or in such moments of searching for orientation. This is a shame, because it is precisely in these processing moments that users—the “earthians” (Fuller, 1970)—would be most open to reconnect with local and global topography in order to localise themselves in relation to the earth. Sometimes such endeavours can indeed be observed by users frequently and repetitively zooming in and out in order to bridge missing information between the different “space envelopes” (Lefebvre, 1991).

In his era, Richard Buckminster Fuller (1969)—an important architect, researcher, and visionary—had an holistic view, understanding our earth as a unique biosphere in the vast universe. Already at that time he proposed different terms to remain faithful to his understanding of what he referred to as “Spaceship Earth”:

I suggest to audiences that they say, “I'm going ‘outstairs’ and ‘instairs.’”

At first that sounds strange to them; They all laugh about it. But if they try saying in and out for a few days in fun, they find themselves beginning to realize that they are indeed going inward and outward in respect to the center of Earth, which is our Spaceship Earth.

And for the first time they begin to feel real “reality.” (Fuller, 1969, p. 78)

Following this idea, Professor Ursula Heise (2008) from Stanford University proposes a shift away from “a sense of place to a less territorial and more systemic sense of planet” (p. 56), pointing instead towards the spectrum of scalar levels that lie in-between. The question arises how this change in our thinking about our planet earth could possibly be achieved. In an attempt to address this, I will look further into Fuller’s concept of Spaceship Earth and his suggestions in order to reveal further aspects of how to design a visual concept.

6.3.2. Our Sense of Place after Buckminster Fuller: From Biosphère to VR

Fuller (1969) proposed and lived a quite different understanding of place. Words like “down” and “up” seemed bizarre to him, since they refer to a planar, flat concept of direction that is inconsistent with the actual human experience. According to Fuller, the words “in” and “out” should be used instead, because they better describe an object’s relation to a gravitational centre—the earth. “World-around” is another term proposed by him to replace “worldwide” (Fuller, 1969, p. 82). Suggesting that the general belief in a flat earth died out in classical antiquity, Fuller distributed as far as he could his concept of Spaceship Earth, noting: “The most important fact about Spaceship Earth: an instruction manual didn’t come with it” (p. 82). Fuller designed my favourite architectural

construction: the Biosphère (1967) in Montreal, which functioned as the United States of American Pavilion for Expo 67.

However, today Fuller's concept of Spaceship Earth and his idea of thinking towards a gravitational centre seem to be largely forgotten by the public. The question that should be asked is whether spherical media formats would not be more appropriate to represent this concept, representing the earth in a spherical form and allowing one to go in and out whilst travelling around or zooming into it. Contemporary technologies, such as VR or spherical dome projections, such as the Immersive Vision Theatre (IVT) at Plymouth University—showcasing artistic immersive productions during the Balance Unbalance Conference 2017⁶—have made spherical visual concepts available to a broader audience. In the VR field, the application Google Earth VR, experienceable via the HTC Vive, is also worth mentioning. The user is inside a 360° cosmic environment, observing planet earth, which can be interactively scaled. The earth can be observed quite closely in its entirety, due to the wider field of vision and the 360° visual space of the HTC Vive—a vision much wider than a flat representation would allow for. Since the software is linked to Google Street View, one can choose to fly deeper into, and thus inside, the earth's topography—into a continent, then into a country, into a three-dimensional cityscape, and finally into a three-dimensional street view, which allows one to

⁶ See <http://balance-unbalance2017.org/>.

move through the streets and occasionally enter 360° spherical photos of that particular location.

Is this then not following Fuller's (1969) argumentation path, enabling any person to "begin to feel real 'reality'" (p. 78) through the practice of navigating "around" and "into" a three-dimensional model of the earth? Additionally, new spaces can be entered and navigated. The model of the earth can be further individually complemented by one's own local 360° spherical photos. It is through these embodied engagements and individual performances, and not the isolated brain, that mechanisms for reasoning and imagining are created, enabling "eureka" moments and abstraction.

Creating such experiences and participating in them fluently can potentially change our thinking and augment our imagination, allowing the local and the global to become connected in our imagination and thinking, and subsequently having a tremendous impact on our behaviour and—hopefully—on the earth's environment. I would like to coin this process of reconnecting, extending the mind-concept of the world, allowing us to externalise the inner concept towards an outside virtual environment, performing and creating inside of it—processes of enacting new ways of thinking, which are "passage" moments.

I would like to emphasise that the passage concept is not merely an artefact with an epistemic function, nor a construct that has only representational functions. Rather, I would like to expand the passage concept towards

Malafouris and Renfrew's (2010) "cross-disciplinary unifying framework" (p.9) of "the cognitive life of things," which is explained as follows:

Our conception about the cognitive life of things encompasses much more than a simple reconfiguration or spreading of our modes of mental encodings (from in-the-head to in-the-world). Our vision of the cognitive life of things is inspired more by the hybrid image of the potter skillfully engaging the clay to produce a pot, than by the linear architecture of a Turing-machine.

(Malafouris & Renfrew, 2010, p. 3)

In other words, the enacting moment is in focus. The question of what kind of minds are being constructed by the perceiving and undergoing of such a virtual passage experience takes prominence over the question of what kind of mind was needed to make such an experience.⁷ Malafouris and Renfrew (2010) further base their framework on contemporary philosophies regarding the extended, distributed, and embodied mind. They state that the externalist outlook—i.e. recognising that the inner, mental state is determined by elements of the external world—has been taken further by "active externalism," meaning that not only content, but also the mental process, can be external to the subject (Malafouris & Renfrew, 2010). At the core of this line of thinking lies the "parity principle":

⁷ Paraphrased from: "What kinds of minds are constructed by perceiving those images?" instead of "What kind of mind was needed to make those images?" (Malafouris, 2007, p. 295).

[I]f, as we confront some task, a part of the world functions as a process which, were it to go on in the head, we would have no hesitation in accepting as part of the cognitive process, then that part of the world is (for that time) part of the cognitive process. (Clark & Chalmers, 1998, p. 8)

These embodied, connected engagements generate techniques for reasoning and imagination. Amongst the fine distinctions between thing, object, and artefact, the meaning of the *cognitive life of things* might be found, inside “a process that characterizes and allows for the *passage* and interaction between the states of thingness” (Malafouris & Renfrew, 2010, p. 4, emphasis added). If we now presume that the thing is the concept of passage, which we made experienceable through a 360° spherical zoom practice, then how can this thing change its state of “thingness”?

Video > space

First, it can change from being a video projection of a moving image to being a real spatial environment, which coordinates the way in which we accept and (re)orient ourselves inside it.

Space > local, known place

The space we are in can change into a familiar place, such as our home city—a place we can connect to on an emotional level, because we know nearly every corner and every street.

Local, known place > planet > universe

Eventually, this known place can change through a zooming passage into an extended understanding of planet earth. Home then becomes not only the local city, but the whole planet and possibly the solar system, or even the known universe.

My aim is further to connect the concept of passage to Malafouris and Renfrew's framework, making it exemplary of "the cognitive life of the passage concept" whilst showing some practical artefacts that I created with my project "Superheroes of the Deep Sea" for the scientific year of the oceans (*Wissenschaftsjahr 2016*17 – Meere und Ozeane*).⁸ Yet before we immerse ourselves further into the creation of such passage moments, we first need to consider the difficulties that may arise in the designing process of transitions inside a spherical environment.

6.3.3. The Problem of Scale Transition in Spherical Environments

Creating content for spherical environments such as domes and planetariums for nearly 15 years, I have come to realise that there are specific moments of scale transitions that become more problematic as they become more abstract. In other words, as further scale regions are reached, the more difficult it is to keep the orientation and the connection with the content. There is a peculiar moment of interruption. We see suddenly an unfolding data landscape, which

⁸ See <http://www.hochschulwettbewerb.net/superhelden-unserer-ozeane/>.

can be tremendously beautiful and aesthetically overwhelming, yet we have no idea what we are looking at. In such moments the visualisation can be reduced to little more than a visually attractive screen saver. A total disconnection between the acts of seeing, sensing, and connecting takes place—the inner mind cannot internalise the projected virtual world (Malafouris & Renfrew, 2010).

This is precisely what could be re-established inside a transition moment, which would be the passage moment we are looking for. Many viewers cannot explain precisely at which moment they realised that they were losing their connection to the content before them. This might have to do with the fact that no one likes to admit being lost—not even to oneself. Additionally, we tend not to analyse or reflect upon our thinking processes automatically. Yet what we can say is that, as human beings, we are trained through our formal education to make sense of nearly everything. Thus, the mind will try to reconnect with the displayed visual over and over again, trying to catch numbers, words, or any extracts as the scaling transition continues and new input appears. Very slowly there will be less and less familiar things, signs, and patterns that may allow one to reconnect with the known mind-concept, which is rich in daily, bodily interactions with our local environment. What we see has nothing to do with our known bodily experiences, and since no recognisable extract of information is coming through, we slowly get tired, as the mind decides there is nothing it can do anymore to put itself to rest and to save energy. These effects can be observed in many dome programmes and shows: half of the visitors will lay back and fall asleep, whilst the other half will secretly try to log into their favourite

social network accounts if a Wi-Fi internet connection is available and the light source is not disturbing the darkness of the theatre, causing undesired attention.

Other phenomena that add to this problem, especially in the context of scientific visuals, are the two forms of invisibility suggested by Mersch (2005). Mersch states that we face a double invisibility since we do not understand what we see, or the mechanism through which we see it.

Additionally, the taxonomy of the dome itself can be difficult when it comes to providing spatial orientation. The distance between the spectator and the dome's surface—and therefore the visual—can be quite long, depending on the size of the dome, which can vary from 3 to 30 m in diameter. For example, the sublime effect, in which the dome shape disappears and we are surrounded by the 360° environment, enables us to embrace the universe by floating through it, or shrinks us down until we can find ourselves sitting in the eye of a fly. This experience can be quite delightful, yet at the same time it can very easily disrupt our sense of dimension and proportion in relation to our own body, leaving us quite disorientated. In the following subsection, the concept "Powers of Ten" (1994) by Charles Eames, as well as the concept of artefacts as tools of thought in general, will be examined to find more answers to the question of how we can overcome such disorientation.

6.3.4. Concepts that Help Us Think and Orientate in Space

With his movie and guidebook “Powers of Ten” (1977), Charles Eames presented an architect’s perspective and his architecturally-driven view and visual knowledge of the world via definite spatial examples and proportional comparisons. Eames created assemblages of objects—assembled according to size—from the smallest to the tallest objects on earth in relation to the human body. The objects ranged from blood cells to the highest mountains—objects that we could possibly still encounter, but that would not automatically be put next to each other because of their common parameter scale (Eames, 1994).

In order to move the imagination further into the micro or macro dimensions, Eames used a chain¹ of relation—or *orientation* chain—by the factor 10—an imaginable relation chain that allows one to orientate oneself, even in more abstract and remote environments. Through the visualisation of a comparison chain, new epistemological connections between imaginable and yet unfamiliar structures are enabled. Remote locations can be made familiar through spatial experience inside the IDE. This chain approach can be enriched through a spiral camera movement to allow more perspectives of the full 360° environment of an IDE while passing through different scales particularly inside the transitions from one environment into the next.

The *orientation* chain by the factor 10 can further be used for artworks: for example, if 10 inhabitants from 10 different cities tell 10 personal, different narratives in the context of urban architecture every 10 years to uncover

common patterns in the context of smart city development, relations and patterns would appear that would otherwise remain invisible, as discussed by Cesar Baio (2017) in his paper for the Balance Unbalance Conference 2017. Baio (2017) looks specifically at spaces of failure—non-existing spaces in urban visuals; spaces that need to be completed by our own imagination.⁹ In a similar sense, the bridging of scales can be imagined by the viewer, having a much stronger lasting and epistemic effect than showing a transition one by one (1, 2, 3, 4, etc.) in its fullest detail.

Here, Marshal McLuhan's (2005) theory on cool and hot media can be informative in order to explain this effect more clearly. According to McLuhan, a hot medium allows for less participation than a cool one—for example, a book allows for less than a dialogue. Cool media are high in participation, or require completion by the audience (McLuhan, 2005, p. 25). By means of an example, McLuhan uses a cartoon, stating that very "low definition" is provided here in comparison to a photograph, which is high in definition and does not leave any gaps to be completed by the viewer (p. 24). In order to create a concept or an artwork that would not only help us think, but that would also activate a deeper participation—as with McLuhan's cool media—in his panoramic photography projects Baio (2017) is fighting against the automatic algorithm by manually

⁹ This technique has been used on a much smaller scale for quite some time now in the cinema, for instance, by left and right counter portrait during a dialogue—the missing space in-between is imagined automatically by the viewer.

stitching specific corners of the surroundings next to each other and purposefully leaving out the spaces in-between the corners, consequently resulting in a sort of individual collage of a specific urban environment. This way Baio leaves open gaps to be completed by the viewer see Figure 6.3.



Figure 6.3. Spaces of Failure. Marquês de Herval Building, photograph series by Baio, 2014.

Baio's creative and artistic approach, resulting in an urban structure that is intended to be interpreted individually, can also be connected to Clark & Chalmers's (1998) idea of "surrogate material structures" in order to extend this concept a little further. In Clark's view, such proxies refer to any real-world structure, artefact, or material assemblage. They are being used to "stand in for, or take the place of, some aspect of some target situation, thus, allowing human reason to reach out to that which is absent, distant or otherwise unavailable" (Clark as cited in Malafouris & Renfrew, 2010, p. 7). Exactly this moment, when the mind is being encouraged by a visual structure to reach out to what is absent or would normally not even enter the thinking process, is of tremendous interest to me. This experience could be most effective in scaling transitions—both into the micro and into the macro.¹⁰

¹⁰ It reminds me most intensively of my first participation in a cosmic journey moderated in real-time by Steve Savage at the Munich Planetarium, which reopened especially for this event. Only then, for the very

6.3.5. An Introduction to “Superheroes of the Deep Sea”

To sum up, with regard to the concept of passages, we are looking at invisible structures that are preconditioned by “visual tokens”—immersive journeys through different scales, proxies, and incomplete assemblages that can help us to activate thinking in new ways. As mentioned above, in order to find a practical approach to the concept of passage and test some of its practical artefacts, I envisioned and realised with a team of around 12 members the project “Superheroes of the Deep Sea” (Beyer, 2017).¹¹ The passage experience for this project is realised through a descent into the deep sea, stopping at three stations at different depths. For the conference Balance Unbalance 2017, this project was chosen to be displayed in the Immersive Dome Theatre (IVT) and through my own pair of Samsung Gear VR goggles, which were employed as a deep sea diving station.

first time, I could start to feel and imagine the spatial relations much better than beforehand—my mind-concept was extended, and with each step we flew further away from the earth’s centre.

¹¹ The team consisted of Isabella Beyer, Eduard Thomas, Gert Hoffmann-Wieck, Joachim Perschbacher, Michel Magens, Bob Weber, and Kirsten Baumert, among others.

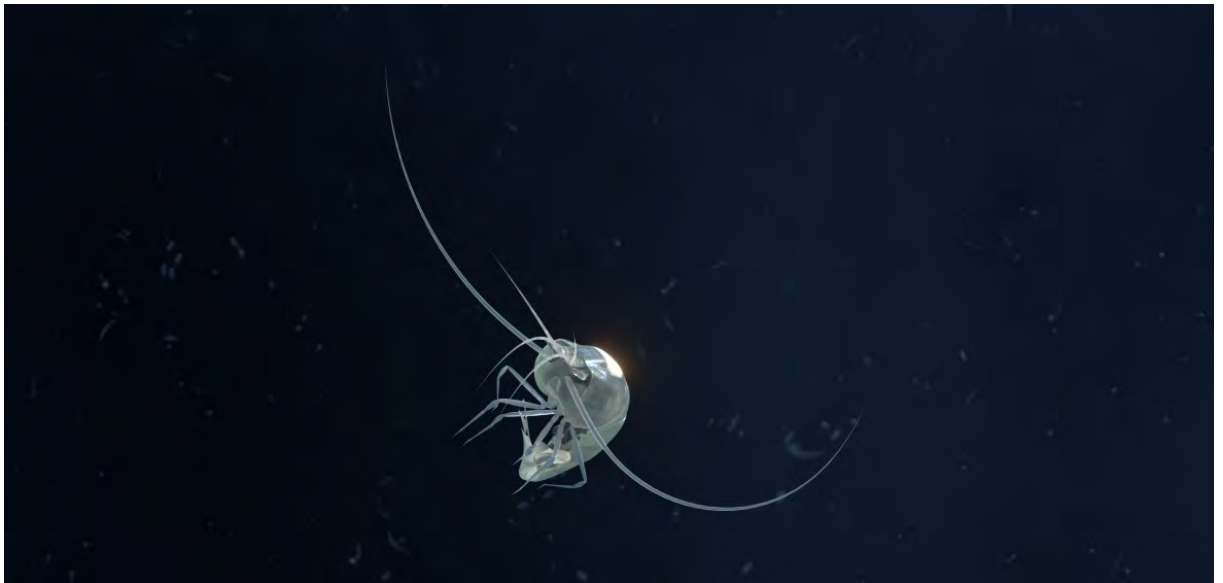


Figure 6.4. "Superheroes of the Deep Sea," 2017. Photograph by Isabella Beyer, 2017.

For me, the aim of the project was not only to develop a concept for spherical dome projection—as I usually do, and which is always limited to a smaller target group of planetarium visitors in each city—but to realise a transmedia concept, resulting in a transmedia storytelling project tailored to many different media formats, including fulldome, AR application, VR full spherical and stereographic format for Samsung Gear VR and Oculus, and interactive 360° videos for Internet, social media channels, events, and exhibitions in order to allow for an open dialogue between scientists and the general public. Additionally, I made video documentaries of the events for those who could not attend. The challenge was to find the right moments and experiences that would best suit each individual medium. The project could only be accomplished and financed because the concept and the storyline won an award by the Wissenschaft im Dialog (WiD; Science in Dialogue), an initiative of Germany's scientific community on the topic of the current German Science Year: Seas and Oceans 2017. The initiative asked for submissions from universities and research

facilities in order to make their research in the context of the oceans visible by communicating and preferably interacting with local communities. The main aim of the project is to sensitise the public towards the fragile ecosystem of the deep sea and its inhabitants.

6.3.6. The Concept for “Superheroes of the Deep Sea”

There were several questions that needed to be solved in order to fully realise this concept: How could spherical media formats help to create a new awareness of the ocean and the planet? How to give this remote environment a voice, which otherwise cannot be heard? How to raise awareness for the deep sea and its wondrous, fascinating organisms? And how could the concept of passage possibly be weaved into this experience, creating an unforgettable, extended involvement? One possible way was via the research field of geology, explaining the origin of hydrothermal vents on the deep sea floor, including the movement of continental plates, etc. However, together with Dr Gerd Hoffmann-Wieck from the Helmholtz Centre for Ocean Research in the city of Kiel, and Eduard Thomas, the Director of the Kiel Planetarium, we decided to concentrate on life forms in the deep sea, as they spoke more to us and we assumed the same would apply to the public. Thus, I chose three organisms—namely, the deep sea barreleye fish (*Macropinna microstoma*), which we chose to call the observator fish due to its specific eyes, living at a depth of 400–2500 m; the pelican eel (*Eurypharynx pelecanoides*), living at 500–7500 m; and the wondrous eyeless shrimp (*Rimicaris hybisae*) see Figure 6.4., living at depths of 2300–

6000m—to be the three superheroes of our project. They were selected for their outstanding capacity to survive in this lethal environment, with nearly no food and under the highest pressure, created by the immense volume of water between their bodies and the ocean’s surface.

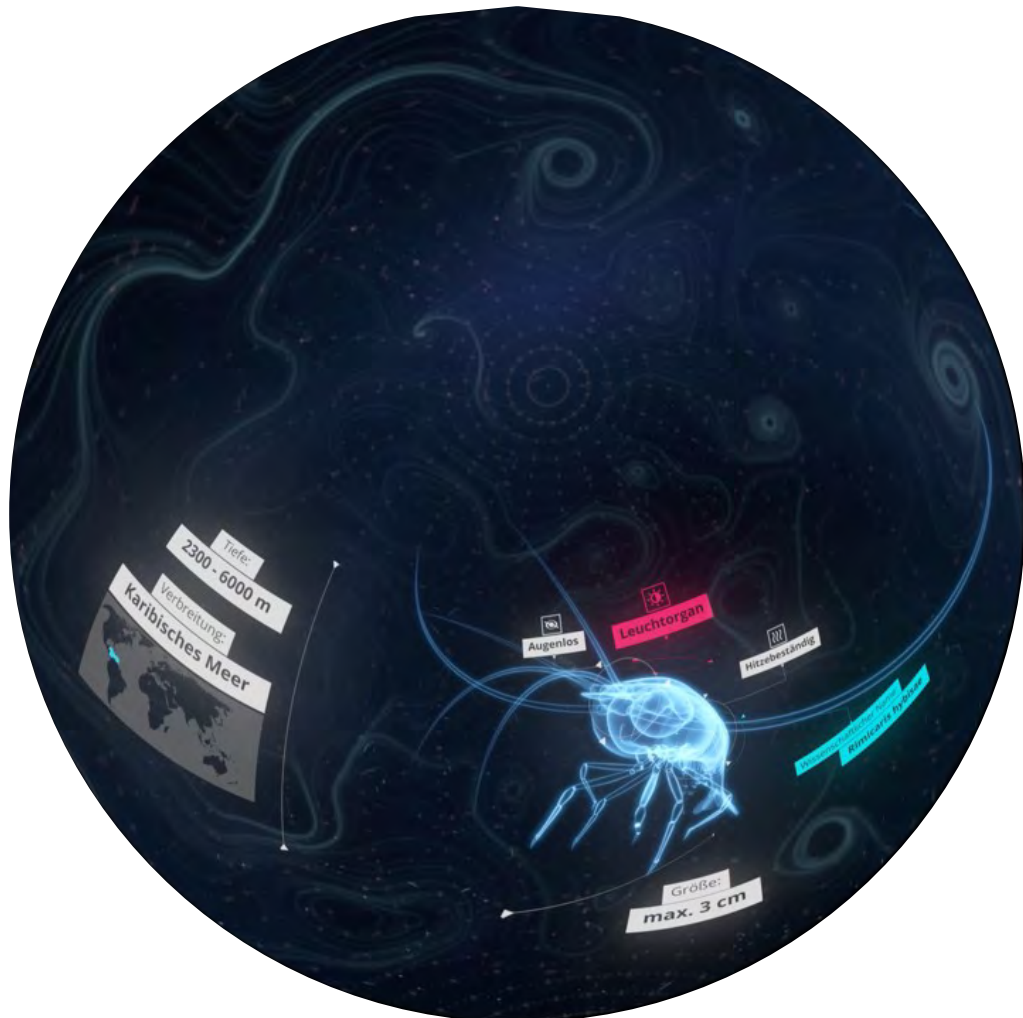


Figure 6.5. “Superheroes of the Deep Sea,” Isabella Beyer, 2017.

The first passage would be realised through the sinking and slightly spiralling movement in the spherical environment with three distinctive stations, which were allocated to the living regions of each animal in the deep sea. Arriving at this station on a particular depth, a passage for each organism was designed. An

individual sphere could be entered by each animal, starting a scanning process. Within this process the animal is scanned, whilst its movements are simultaneously rendered in slow-motion—as if time was standing still—thus creating both time and space for all the different perspectives. These passage moments were created in order to offer enough time to engage with the individual organism and to discover the distinct features that had afforded the particular animal the status of “Superhero of the Deep.” The passages and transitions were intended to evoke a sense of place—or more precisely, of the sheer volume of the ocean. This included a new way of thinking about scale, the relation of size, and spatial knowledge. Through a spherical spatial representation, hopefully our thinking—contrary to flat, rectangular screen-based thinking—will change beyond and towards the gravitational centre of the earth, therefore creating a “sense of planet.”

During the week-long exhibition that took place during *Kieler Woche* [“the Kiel Sailing Week”] 2017, the three organisms were presented in a mobile dome and in VR.¹² Participants were invited to take a deep sea dive at our VR Deep Sea Station, or to observe the animals swimming by in the dome. It is needless to say that the VR Station attracted the most visitors. Even though they could experience the animals in the dome as well, and were told that they would encounter the same content presented through the VR glasses, the visitors still preferred to wait for half an hour or longer to make the dive wearing the

¹² See <http://www.kieler-woche.de/>.

goggles. One might suggest that the apparatus itself was attracting them, which was quite possibly the case. Yet, when asked how they had experienced the VR Station in comparison to the dome, they would describe the VR experience as more intensive. Some participants cued even a second time to be able to repeat the VR dive, and many came back during the week, bringing their whole families with them.

6.3.7. Challenges: Spatial Relation, Orientation, and Localisation

Importantly, the spatial component, which was intended to give the participants a sense of space in the ocean—a size relative to their own body and additionally between the three organisms—proved the least satisfying. Participants were most frequently asking where the dive took place, in which ocean, how deep the dive would go, and at what depth the organisms live. All of these questions were related to spatial relation, orientation, and localisation.

Although participants were deeply touched and fascinated by their personal encounter with the three organisms through the IDE and VR and they were able to recognise the different parts and features through the three-dimensional representation, they were still unable to ascertain the correct proportions of the animals. Most participants thought they would be much larger than they really are. Spatial comparison in the context of size did not work, even though each animal was accompanied by a sign telling and showing its size. In order to solve this misconception, I thought the best possible solution would be to give the

participants something physical at hand—something non-digital. Thus, the three organisms came into existence through 3D printing in their distinctive real size. At the premiere in the Kiel Planetarium (Mediendom), the 3D-printed Superheroes were exhibited and could be compared with their digital representation in the dome (Figure 6.6).

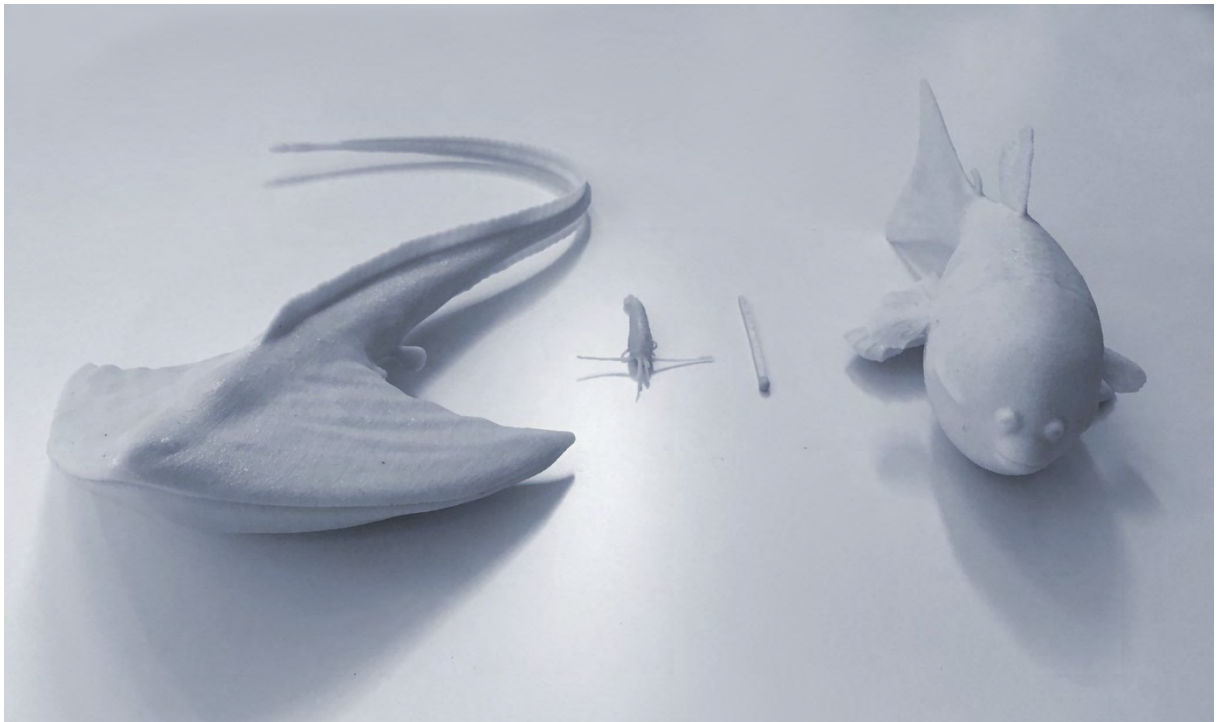


Figure 6.6. 3D prints of the deep sea Superheroes. Photograph, Isabella Beyer, 2017.

Presenting “Superheroes of the Deep Sea” in VR through the Samsung Gear VR at the Kiel Science Outreach Campus (KiSOC), a joint project of Kiel University (CAU) and the Leibniz Institute for Science and Mathematics Education (IPN), evoked a similar reaction. The relative size of the organisms to each other was not clear. Only when I presented the 3D prints afterwards in the exact original size did I observe an “eureka” effect in the participants. I experienced exactly the same thing the first time I saw them coming out of the 3D printer: although I was

familiar with the 3D models of them on screen, only then could I really think *through* them. This was true especially with regard to the eyeless shrimp, being so small, measuring 3 cm and resistant to a temperature of 450°C—it left an emotional impression on me. From this moment onwards, it secretly became my personal Superhero favourite.

As described above, both the dome and the VR situation clearly pose a problem with regard to spatial passages and spatial relations to our own bodies as well as between objects appearing in space. As the Superhero project demonstrates, the concept of realisation needs to be analysed further in order to enable a size orientation. The VR dive-experience was realised using the Samsung Gear, which functions as a VR video playback. Therefore, it is more a 360° video than a real interactive playground. The VR video offers a slightly enhanced situation regarding presence in comparison to the dome playback. Participants feel more present than in the dome, as they are fully immersed inside a whole sphere—up and all the way down, including a slightly interactive component in the form of their individual looking directions. This is the gyroscope function¹³ of the mobile phone sitting inside the VR goggles. Through physical head movement, the participants choose their section of the spherical visual, determining where to look within the given field of vision. Already this function slightly adds to the feeling of autonomy, which is more present to the participant than in the dome.

¹³ Mobile phones today have many highly sophisticated tracking functions and sensors, such as the accelerometer used for fitness apps; the gyroscope for orientation; the magnetometer as a compass; GPS; and further sensors, such as the ambient light sensor, proximity sensor, or barometer for air pressure.

Yet, it is still not sufficient. In VR participants interact with the environment through head movement, but they are not connected to the spatial physical environment because the reference and thus the linkage to their own body is missing.

To address this problem of detachment during scale or diving passages, a further, deeper interactive approach in VR could be added, for example through the use of HTC Vive, which allows active participation and interaction with the VR environment in real-time via two controllers. First, the participant's own body is represented in the VR environment, with the hands (and possibly more) representing the controllers. Taking the shrimp and seeing its proportions in relation to one's own hand would then be possible. The participant can decide at any given moment to interactively zoom into the shrimp to the micro scale—to the level of bacteria and the interactions between them. During this interactive zoom passage, the participant has the opportunity to zoom out again at each scaling station. This enables one to regain the orientation that one has lost, and can be repeated endlessly.

6.3.7.1. The Spiral Manner of Scaling

The spiral manner of scaling enables spatial orientation and understanding. It is one of the strongest concepts in both the 360° visual space and in this dissertation. The technique provides new ways of visual comparison leading to spatial understanding, particularly when transitioning from one environment to

another, or from one scale to another, resulting in an epistemological passage experience. The spiral movement allows a relation of size in the spherical environment at one glance.¹⁴ Therefore, scaling needs to occur in a spiral manner in order to allow a relation of size to be maintained in the 360° visual space—when we reach the next scale, we can still see the larger (slowly disappearing) former object by moving our heads, allowing us to connect to its size whilst simultaneously already seeing the next, smaller object. That way we are spiraling deeper into the next scale while still keeping an omnipresent overview.

On demand an additional intelligent network of numbers, visual tokens, and size indicators can appear during the scanning process. Also, additional objects on earth that have the same size can be displayed at each station in a scan aesthetic. This way the intended sense of ocean space and the size of the animals can be realised. Three-dimensional sound adds a further, very important immersive layer to VR experiences, and should be included as well: when objects move from right to left, up and down, or back and forth, they can be accompanied by similarly moving sound. Sound can travel the same path spatially, allowing for an even more intensive and deeper experience of being

¹⁴ This concept was explored in chapter 5.5.3. The IDE used as a Camera Instrument; 5.3.1. The IDE's Creation "Descent to the Deep" [Buczek, 2007]].

present in the virtual environment. This can also help participants to orient themselves in the presented space.

The realisation of the concept described here establishes a link between the body and the experience right from the outset. Through interacting components, it enables the participant to be fully autonomous. Further to this, the problem with distance perception in the water and the size of the animals can be solved by including a reference to the participant's own body. Additionally, the geographical location of the dive needs to be visually established. This way the required orientation that many participants needed can be provided. Otherwise, the mind is preoccupied with trying to answer such questions, trying to localise itself in relation to the space around it and thus, whilst doing so, unable to focus fully on the experience of the dive itself.

6.3.7.2. Other Media Channels

Another media channel has been tested with AR using a mobile phone and a small sticker 3 cm in diameter as a trigger, as presented in Figure 6.7.



Figure 6.7. AR experience: The eyeless shrimp. Photograph, Isabella Beyer, 2017.

The idea behind this application was the improvement of scale comparison between the eyeless shrimp and the human hand. An image of 3 by 3 cm was used as a trigger for the virtual shrimp to appear. Once the mobile phone was placed above the trigger image, the rear-facing camera of the phone could trigger the image and the virtual shrimp could then appear on one's hand. This application was tested in order to analyse if this performance helps the user to realise the exact proportions of the shrimp in relation to one's own hand (see Figure 6.8). Although this proved to be quite helpful, it did not get as much response as the physical and haptic 3D-printed model of the shrimp and the 360° experience in the dome or through the VR goggles.

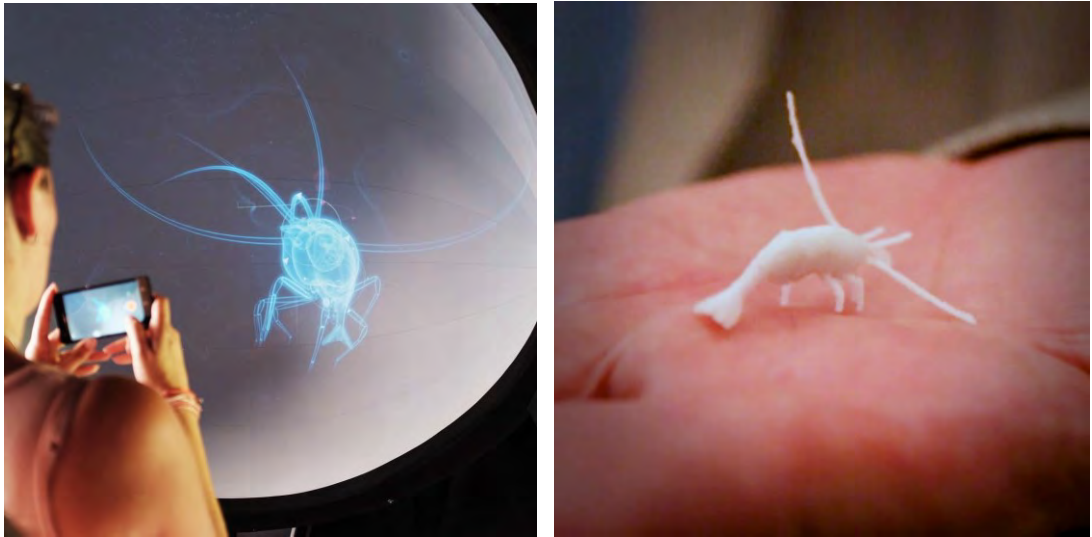


Figure 6.8. The 360° encounter versus the haptic experience of the eyeless shrimp. Photograph by Isabella Beyer, 2017.

Concluding, one can say that the 360° encounter cannot be substituted by the haptic experience, nor vice versa. Rather, both experiences productively blend with one another. In order to reach a better sense of place and planet—in this example a better sense of the space under the ocean’s surface—the passage concept in either VR or the IDE proved most promising as a diving and sinking passage, meaning participants could sink deeper and deeper into the ocean, eventually reaching the site of a hydrothermal vent. This concept generated the most interest whilst on display over the course of nine days.

The “Superheroes of the Deep Sea” project illustrates how illuminating a transmedia approach can be. It also taught us exactly what each media channel is capable of, as well as their respective limits. I decided to use the transmedia framework in my master’s module in Multimedia Engineering VR at the University of Applied Sciences Karlsruhe 2017 (spring session) and will continue to do so at the Lübeck University of Applied Sciences. This framework has

resulted in innovative and individual student artworks and prototypes. The prototypes ranged from a VR jump “Once through Earth” to a AR solar system around the castle of Karlsruhe, as described in subsection 7.2.3. of this chapter.

6.4. Conclusion: Passages in IDE, VR, AR, and MR

This case study—my own project “Superheroes of the Deep Sea”—was used to illustrate not only a transmedia concept, but also the possible points of interaction between different media formats, such as the IDE, VR, AR, and MR applications. The VR experience was introduced as a deep sea diving station, blending into the overall context of the deep sea and connecting it to a normal, real-life activity with which visitors can connect. I demonstrated how the passage concept is used in contemporary 360° media with the purpose of easing the transition from the physical environment to the virtual, and enabling orientation.

Further, the fragile epistemic and splintered spatial perception (Mersch, 2011; see also the introduction of this thesis) caused by our daily use of media and the already common phenomenon of being in many different digital spaces at once via our use of navigational tools, virtual spaces, chat rooms, or talking to friends in different countries can be taken into account. Throughout my research, in the multiple and omni-perspective of the IDE, I found fluent spatial passages very helpful. Using this technique, the spatial chain concept (powers of ten) can enable scale comparison and self-determination of one’s own position—both on earth, and in the universe. The fractured puzzles and patterns of our

environment that originate from our splintered perception can be complemented by 360° passages.

It can be said that both media formats can learn from each other: the new VR industry can learn from the IDE¹⁵ how to tell stories, navigate, and create transitions in the 360° coordinate space such as the scaling in a spiral manner, whilst the IDE can equally learn from the field of interactive VR. For example, new scenarios from the field of VR games could be beneficial for the IDE, allowing it to tell stories from multiple perspectives, both interactively and non-linearly. The Google Earth VR application, for example, has some aspects—such as individual navigation in real-time—in common with the Digital Universe Atlas (DUA) as used in planetariums, allowing interactive exploration.

All these media developments demonstrate that the ways in which stories are told are constantly changing. The DUA, for example, is a universe model, rather than a story or a single storyline, whilst Google Earth is a model and a whole world on its own. Both approaches teach us a perspective shift towards the concept of building worlds and models, rather than a contiguous storyline. Today's storytellers become world and model builders, whilst the user or recipient becomes the storyteller of his or her own story through individual performance, interaction, and experience within that environment or world model or knowledge container.

¹⁵ Please see Chapter 5 for more information on designing environments and telling stories for 360° coordinate spaces.

Conclusion: Future 360° Passage Concepts and Their Role as New Knowledge Instruments

As a motivation for this dissertation, I reflected in the introduction on the philosophical and problematic context of our splintered existence—one fragmented via multiple forms of media technology. This was further problematised in my opening address on Freud's three humiliations of humanity, upon which I expanded by introducing the limitations of our human perception as a fourth. This perception is further distorted through our daily activities and our actions in different digital spaces simultaneously. Our spatial orientation is also fragmented. The use of navigational instruments and Google Maps now informs our spatial perception and a specific spatial memory; a process by which a continuous intertwining of the real-physical and the media-virtual takes place (Jaschko, 2011, p. 115). The use of different, predominantly two-dimensional navigational devices coupled with diverse visual inputs leads ultimately to gaps in our spatial imagination—not only of our local environment, but also our place in the universe. In order to address this problem, I propose the concepts of transitions, fluidity, and most importantly, connectivity through passages that blend between different media platforms and between different spaces—both the real and the virtual—constructing corridors and contextual connections. These passage corridors can be spatial arrangements of knowledge, and present new, in-between spaces (Mersch, 2006). With their

specific topological structure, they provide access to new information through arrangements, patterns, and relations. Such passages can both eventually complete our spatial perception and widen our spatial understanding of the world we live in.

This conclusion presents and summarises the answers to the research questions posed at the beginning of this dissertation regarding the passage concept—its efficacy and its future development. Further, an examination of the future of the 360° environment itself will be provided. The passage concept as a new knowledge instrument and its usage in immersive spaces will be reviewed and presented—including its future as a valid concept that is expandable into emergent spherical media technologies such as AR, VR, and MR. Finally, this conclusion will look to the further development of the dynamic Digital Universe Atlas (DUA) model, as well as giving possible future scenarios for its use as a dynamic model.

Research Questions

The following research questions were posed at the beginning of this research and are to be found at the beginning of the introduction to this dissertation.

Are there historical precedents, models, and approaches that can frame the immersive space as a knowledge instrument?

When studying the IDE's historical precedents, it soon becomes evident that of the greatest significance for these concepts was—and remains—the transitional state, realised as the merging of the scientific with the artistic. This transitional

mechanism allows for the realisation of threshold moments through visualisation—for instance, the lift-off in a hot air balloon, seeing the earth from a fully new perspective whilst drifting upwards; the journey around the world inside the first planetarium via a star projector; and the development of a truly kinesthetic medium made possible by the more recent fulldome planetarium. Inside the fulldome planetarium, passages through three-dimensional star constellations illustrating the real spatial arrangement of the stars in the cosmos that break with the rigid perspective from earth are possible. Through these passing experiences a new perspective and sense of spatial knowledge can be reached. Therefore, a passage can have a strong transitional effect, imparting both knowledge and a greater sense of one's place in the cosmos.

Looking back at other historical presidents, models, and approaches that can frame immersive space as a knowledge instrument, I found the concept of the georama to still be a valid one, not least since it illustrates perfectly the paradoxical nature of the sphere, being simultaneously within and without: even when on the inside of the globe, we can still observe its exterior. This concept is still used today, as for example in the show *Habitat Earth* (2015) by Ryan Whatts, Director of the Morisson Planetarium in San Francisco, or as can be found in the *Termespheres* designed by Dick Termes. The georama is certainly a taxonomy that deserves much more attention by contemporary dome artists.

What is the epistemological function of immersive space as a knowledge instrument?

The immersive space as a knowledge instrument has two main epistemological functions: The first is its ability to be a metamorphic instrument—a shape shifter, in other words, having the faculty to transform its behaviour and form.¹ The second important function of immersive space is its ability to act as a vehicle, and therefore as a passage instrument. This function was illustrated via several concepts, starting with the genesis and usage of the all-around view in 360° artworks that aimed to empower the visual effect—for example, for travel and lift-offs from the ground—such as at the Exposition Universelle, a World's Fair held in Paris in the 19th century, right up to its contemporary use, for example, a narrative journey inside the DUA model of a fulldome planetarium (see Chapter 1). Mastery of spherical media has been achieved, as a result of both technological breakthroughs over the centuries, and human ingenuity and perseverance in learning how to deal with, and create, visual space itself. Whilst in the early days of immersive space development, endless effort was expended simply to give the illusion of passing—either by a ship, a train, or a hot air balloon (constructions in the 19th century)—the motorised era demonstrated that the age of the 360° visualisation had now truly arrived.

One of the most important developments of the current era is the three-dimensional model in digital space, named the DUA, in which universe passages have been made possible. This interactive spatial dynamic model of the universe allows multisensory passage experiences inside the IDE. Whilst the IDE has also

¹ In this dissertation the IDE (the Immersive Dome Environment of a fulldome planetarium) was extensively elaborated as an example of immersive space.

become a passage instrument in itself, with the ability to transform into different vehicles and allow a corresponding passage experience. Examples of planetarium shows that use the IDE as a vehicle for different passages to great effect are “Dream to Fly” (Majda & Buczek et al., 2013)—produced by The Heavens of Copernicus Planetarium and including a flying, airplane, and hot air balloon experience—and “The Natural Selection: Darwin's Mystery of Mysteries” (2010), produced by Robert Sip, including a passage experience created via a ship. As an example of a lift-off experience, my own live action shoot with a drone traversing a wind turbine can also be consulted (see Chapter 5). The IDE can thus be considered as a passage instrument from which to gain new knowledge—specifically, spatial knowledge contextualised through a passage event.

What design mechanisms, methods, and qualities can enrich the passage concept and further successfully merge the scientific framework with artistic visualisation?

The spiral technique is an important design mechanism—one that can significantly enrich the passage concept. The circular movement of the 360° visual is already a very strong spatial simulation inside the cupola. The ceiling appears to move, only the bottom of the floor is not. The audience is moved or made mobile when focusing on the 360° visual around them. This effect is very similar to a train passing, which makes us think that we would move although our train is standing. In this simulation, the IDE reveals its full impact as a kinesthetic medium and this quality, when combined with the spiral passage technique, has a very strong effect on the audience as the star constellation example illustrates. The realisation by the audience that the constellations have

spatial depth is a key concept of embodiment, kinesthesia, and knowledge.

Thus, it has been used quite frequently in my fulldome productions. For more on this subject, see 6.3.1. The IDE's Creation "Descent to the Deep" (Buczek, 2007); 6.5.3. The IDE used as a Camera Instrument; 7.3.4. Concepts that Help Us Think and Orientate in Space; 7.3.6. The Concept for "Superheroes of the Deep Sea"; 7.3.8. The Spiral Manner of Scaling for Spatial Orientation and Understanding.

The spiral-scaling passage is the most powerful technique used in, and makes the strongest use of, the 360° environment, particularly regarding transitions from one environment to another or from one scale to another—both of which result in an epistemological passage experience. The spiral technique enables the audience to navigate through different unfamiliar scales, opening up new insights on previously unseen or unreached scalar environments whilst carefully maintaining the orientation chain. Through the visualisation of a scale-comparison chain, new epistemological connections between known and yet less familiar structures are enabled. This way, the known world can be supplemented with new insights inside new knowledge containers. Further qualities, such as peripheral vision and embodiment, can further add to the quality of the experience.

Another important quality was identified with the "inside-outside" maxim (Kraupe, 2005; von Goethe in Trunz, 1981, p. 358), particularly regarding the crucial interweaving between the earth's topology and the cosmos or, in other words, the meeting point between heaven and earth. The inside becomes the outside, and the outside becomes the inside, whilst the 360° visual space

functions as the vital membrane and in-between space that enables this exchange to happen. Through this quality the viewer is simultaneously outside and inside the world whilst participating in the visual content of 360° displays. The complex concept of inside and outside—whether throughout the history of the 360° medium it was a creation process from the inside to the outside, or from the outside to the inside—was addressed in chapter 1.

In addition to these transitional mechanisms, further methods and qualities could be found to successfully merge the scientific approach with artistic visualisation. Indeed, the artistic method and its associated visualisation techniques have in some contexts helped the sciences to discover new knowledge, as described in Chapter 4. An important meeting point between the sciences and the arts can be found in the method of the art of understanding, as well as in the diagrammatic approach—more precisely, in the creative moment that occurs within any creation process, and within processes of pattern recognition. By virtue of its sheer breadth, the question of “what art can do for science” (and of course, the converse) with regard to the generation of new knowledge is infinitely expandable. However, in the course of this dissertation, it has been addressed in sufficient depth so as to offer a meaningful and valid examination of the confluence of the two fields in the context of visualisation in 360° environments in Chapter 3 The Paradoxical State of Visual Models, as well as in Chapter 4 Tools of Thought.

How much influence do contemporary media formats have on the IDE medium?
Are there further concepts that could include new media formats for a more lasting experience?

My final research question concerned the contemporary media landscape and its influence on both the IDE medium and the passage concept. At recent planetarium conferences, I realised that there is growing concern that VR might replace the fulldome planetarium. Specifically, if one can go on a journey through the universe simply from one's couch with a VR headset on, would people still visit a planetarium?

Yet, considering the possibility of personalised guided tours of the universe in VR, the scenario seems comparable to the consumption of music through Spotify—whilst users may listen to music through Spotify, they still go to live concerts. Additionally, the simple fact that everything appears to be increasingly available at our fingertips does not necessarily mean that people will make use of it. In fact, the average user seems more overwhelmed by the choice of content, and hence, hopefully a desire for engaging in group experiences will increase in contrast to lonely VR users sitting in their living rooms. More information on VR with accompanying user scenarios can be found in Chapter 7 Future 360° Concepts in IDE, VR, AR, and MR.

Fortunately, the IDE is a medium that, in the context of new technological developments, continuously evolves. Moreover, it functions as a hybrid hub or nodal point between, and serving, different intersecting media technologies. Whereas in other surroundings two technologies would possibly never meet, in

the IDE they intersect in a fruitful way, forming new experiences. In the analogical sense: when two stars collide, a new star is born. Therefore, the medium itself is in an ongoing transitional state—from 360° movie theatres to interactive VR environments. Therefore—and contrary to the substitution scenario—the experience inside the IDE medium can be complemented through the development of further media formats such as VR, AR, or MR—as I demonstrated via my own project “Super Heroes of the Deep Sea” in Chapter 7. Additionally, the IDE medium offers a productive space in which all of these media formats can meet, co-exist, cross, or blend together, as the Satosphere at the Society of Arts and Technology (SAT) in Montreal has already been demonstrating since 2011. This co-space offers passages between the virtual and the real, in-between different media formats, and inside new prototyping worlds.²

Contribution to New Knowledge, Personal Journey, Self-Reflection

My contribution to new knowledge is demonstrating that in a rapidly developing technological landscape, the fulldome planetarium is still relevant and possesses qualities that other media do not. I illustrate this by prior historical models and important concepts that framed the 360° space as a knowledge instrument. These prior models include panoramas, globes, cineramas, and the first planetariums, right up to contemporary fulldome planetariums. The

² In recent years, SAT has, for example, developed a creation software EiS (Editing for in Situ) for the dome, which is planned to enable a prototyping creation involving multiple individuals working simultaneously from different locations on a single spherical world project. See: <http://sat.qc.ca/fr/eis#section>

passage function has been established inside the IDE as the primary knowledge instrument by virtue of its capabilities as a “shape shifter”—transforming behaviour and form. The IDE can adapt to the context of a particular content and that way it acts as an “empty space”. Its function follows the content. Through its ability to act as a vehicle or as a passage instrument through time and scale, it reveals otherwise unseen spatial arrangements and perspectives.

I developed immersive design mechanisms, taxonomies, methods, and qualities to enrich the passage concept and to reveal potential merging points between scientific and artistic approaches, in which new knowledge can be discovered. Scientific and visual laboratories have been compared and the importance of both visual and experienced knowledge has been emphasised.

Via my own work with fulldome environments, I enable the audience to relate to relevant, contemporary issues, such as the health of the oceans or I facilitate a perspective shift from a sense of place to a sense of planet.

Over the last eight years, my personal journey through this research has taken me from passive playback fulldome productions to interactive components and transmedia storytelling, using advanced media formats such as VR, AR, and MR. With transmedia storytelling, I showed via my case studies and public outreach how different media formats can blend into each other in order to overcome the problem of distortion and acquired size and scale judgement. I am quite happy with the outcome and would like to continue with my research in immersive media in the years to come. Further research could concern spatial understanding and working with participants more hands on in the laboratory.

The Future of a Transcending Medium

By transcending its forms and functions, the IDE elevates perceptive insights and sensation to a new state of the art. Indeed, the IDE could be naturally conjoined with other technological inventions and disciplines. This ability to break down disciplinary boundaries can be attributed to the way in which the spherical environment still acts as a magnet to artists, technicians, and inventors, as it has done for centuries. Its transitional state and its specific spherical taxonomy result in a strong immersive impact (see Chapter 6 for more information on the IDE's taxonomy).

The other reason for its continuing relevance might be its location—in an institutional context—both from the perspective of sourcing funding, and building the right network of people to develop the medium and its applications further. I have experienced this production synergy at several places—at the Melbourne Planetarium (Australia), Kiel Planetarium, Mediendom (Germany), Plymouth Immersive Vision Theatre (United Kingdom), Copernicus Science Centre, and the Visualization Center C (Norway). All of these digital domes are nested within the larger structure of a university or a science centre, each with its own wealth of “on-tap” knowledge spanning many disciplines. This joining and transcending of different disciplines is enabled through technology, data, and more precisely, computer simulation. The incorporation of data inputs from MRT scans, telescopes, satellites, KML files, 3D geometric scans, or other volumetric scans and instruments from multiple disciplines into the dome creates a co-space; a working environment or visual lab. From these data-

streams, models and landscapes can be shaped and made experienceable in 360° for scientists, students, and the general public. In this way, models are shaped directly out of data.³

The Challenge of Oversaturation

There are also challenges to meet, for example the fact we are oversaturated with images online as well as offline, showing us an endless stream of colourful and overwhelming images and videos, such as Mars landscapes and microscopic worlds. Although we do not even always know whether these images are real or from which source they are coming, they are “out there” to be seen. This makes it even more important that when models are being displayed in the dome, their source is fully explained, including the circumstances in which the data have been produced, in which lab, based upon which research questions, and what exactly it is that is being represented—both from a navigational and a spatial perspective.

In other words, proven authentication should always be offered. We should remember Mersch’s (2005) concept of “double invisibility”—acknowledged in the introduction and in chapter 7 of this dissertation—which urges us to make the processes that generate the final image visible. For example, in the final 360° film, these processes could be revealed by placing an insect such as a fly under

³ Models come to being in the following order: data input; processing, meaning integrating in space/ spatial modelling; modelling; processing—in the sense of programming/rendering (3D software) or testing and adjusting in real-time (game-engine); 360° spatial (and/or interactive) experience.

a microscope, and in real-time viewers would see on the dome the fly model or a previously prepared volumetric scan of it. This allows the viewer to become both discoverer and research participant, whilst an actual object of investigation is “on stage”—both in the theatrical sense and the scientific (microscopy) sense.

Future Concepts: Dynamic Living Things

The question now is: How will the use of representation applications inside the IDE unfold? Will the DUA—the digital model according to the concept of “Powers of Ten” (Eames, 1994)—be expanded and complemented into the micro and macro areas until a complete parallel world is created—one that can be simulated and travelled in a myriad different scales (Lühning, 1997)?⁴

There seem to be a main direction. The planetarium industry wants to integrate more and more data into the DUA, until even the finest details are discernable. Additionally, great efforts are being directed towards moving away from the static state of the DUA model in order to enliven it. So far, the virtual universe remains static, whilst the real universe is perceived to be expanding. Therefore, future endeavours will try to come as close as possible to real events that occur in the universe. For instance, real processes that take place in the cosmos and on earth should happen almost simultaneously, in real-time inside the virtual model. In short, the DUA model is meant to become dynamic.

⁴ Similar to the plans of the Globe of Gottorf, which was already intended to represent and display the night sky—in real-time and in accordance with the actual time and celestial movement of the sky (see section 1.1.1 of Chapter 1).

The above scenario was confirmed by numerous planetarium colleagues, such as Carter Emmart, Steve Savage, Mark SubbaRao, and Dr Ka Chun, with whom I have spoken since 2015. All of the above-named planetarium experts are working at their home institutions on further dynamic extensions of the DUA model. Emmart, for instance, works together with Linköping University on software that includes a virtual model of our solar system, but employs the newest data of the space probe *New Horizons* on its mission to Pluto.⁵ Thus, whilst we travel through the DUA passing Pluto, we can see Pluto textured with the newest satellite images of this mission. Visitors can delve into the same data that the researchers have just received, follow the same research questions, and thus ultimately feel as if they participate in the mission.

Specific areas inside the DUA complement current research. For example, one result is that at the very limit of the observable universe, a sphere created by the recent Wilkinson Microwave Anisotropy Probe (WMAP) appears, depicting cosmological radiation. This sphere represents our contemporary knowledge horizon (McConville, 2014). Whilst the macro scales are successfully depicted, it is much more difficult to find the best visualisation concept for the micro scales, which should also exist within the world model. For example, if one travels into the bloodstream of a human hand or into a leaf, this experience is quite different from the work done at macro scales. As an extension of a pre-existing universe model, the visualisation of micro scales is quite difficult to realise, not least as

⁵ See: <https://liu.se/en/article/pluto-close-up>

there are many different hands and many different leaves. This begs the question: why should we choose one particular hand or leaf over another? This problem might only be solved by isolating the micro from the DUA model. Projects such as “Neurotours” (Fisher, 2014; see <http://www.neurodome.org>), “AlloBrain” (Kuchera-Morin, 2007)⁶ and “Murmuration” (Phillips, 2015) already demonstrate the first steps to visualise the micro scales in 360°, for example into the brain regions, albeit in very different, multimodal ways. From 2015 onwards, the company SCISS offers real-time flights called “neurotours” with their software Uniview inside a 3D model of a brain⁷. This is a real-time journey in which the audience is guided by a moderating neuroscientist through data landscapes of a brain. These data sets are authentic and three-dimensional, allowing multidimensional scaling up to millions of times magnification, from CT (Computed Tomography) and MRI (Magnetic Resonance Imaging) scans all the way to two-photon microscopy of individual neurons. The concept of the AllosSphere has a slightly different approach: “Scientists and engineers can work with their data, perceptually and intuitively, the way artists do” (Marsa, 2014, p. 54), transforming the AlloSphere into a new, visual research laboratory.⁸ Dr JoAnn Kuchera-Morin, Professor of Media Arts and Technology, as well as of

⁶ See: https://www.ted.com/talks/joann_kuchera_morin_tours_the_allosphere/transcript?language=de#t-159437

⁷ See: <http://sciss.se/news/id/40>

⁸ In 2007, Dr Kuchera-Morin built a 360° sphere with a diameter of 10 m over three floors at the University of California in Santa Barbara. The AlloSphere is transected by a glass catwalk from which visitors can observe the virtual environment around them. With a joystick they can navigate through various data and explore them (<http://www.allosphere.ucsb.edu/>).

Music at the University of California, understands her AlloSphere as a virtual instrument that enables the simulation of research data, so that the pace of possible new discoveries can be accelerated. (Kuchera-Morin, 2014)



Figure A. Murmuration " in the Satosphere in Montreal: Real-time interaction between physical and virtual particles © Mike Phillips, 2015.

The final artistic project, "Murmuration," by Professor Mike Phillips, uses MRI scans of a brain and represents these data sets inside the 360° dome environment of the Satosphere in Montreal during a symposium in 2015 (Figure A). However, the project uses further interactive possibilities inside the dome, allowing an interactive group experience. When the participants all come together into the middle of the dome, they are tracked, and the camera movement inside the virtual environment accelerates. When the participants move away from the middle, the camera slows down. Therefore, the participants can navigate their journey through the brain environment as a group. These projects show how new scenarios inside an IDE can be used to enable new routes of exploration through the displayed data, enabling interactive, multifold passages—in certain circumstances even experienceable as a group.

Regarding real-time guided journeys inside the planetarium, they are now easier to realise than ever before. Domecasting⁹, includes a connecting and screening technology by SCISS—which allows the sharing of the same content between multiple domes at the same time—seems to have been attracting more usage amongst German planetariums recently, especially when used for broadcasting live moderations. For example, if a specifically invited scientist gives a presentation inside a planetarium, the presentation can be screened at the same time in other planetariums seeing the same content on the dome and listening to the same moderating scientist guiding the presentation.

If we compare all of these different usage scenarios and applications, one common aspect emerges—that real-time passages, either through the cosmos, the brain, or other data landscapes in combination with real-life moderation or an individual, interactive navigation possibility, will continue to be both thought provoking and offer new spatial experiences. With these developments, we can encounter models of dynamic living things whilst studying their behaviour in different scales more closely than ever before.

Most importantly, none of these concepts of storytelling—their methods of communication, experience, and visualisation—need necessarily to be enclosed in a dome-shaped building. It is not the dome as an object or structure, nor recent technology, but the passage concept—which can be told in 360° spaces (even if they might be holographic at some point in the future)—and the lessons

⁹ See: http://sciss.se/Uniview_brochure_digital.pdf

learned from the classical planetarium, the IDE, and concepts such as VR, AR, and MR in general that hold the key to future developments. Perhaps in the future, the concepts outlined above can be told through environments that embrace real, physical holography.

We live in an era of fractal spaces and fractal minds, in need of passages and transitions between otherwise splintered information, applications, media formats, and spaces, immersed in which we now spend most of our time. These final examples show that perhaps we do not need one *grande passage*, but rather multifold, interactive, small passages. Therefore, with this dissertation, I propose a concept of passages that are transitional, fluid, and infinitely interconnected, with the hope that such concepts inside 360° media formats will continue to grow and flourish in the years to come.

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Appendix I: Content Completion

Content completion of chapter 3 The Paradoxical State of Models

The Model of the Quantified Self: The Human Model

Quite striking was the presentation by Jürgen Moritz at the Models of Diversity Conference in Zürich, 2016. Under the title “Empathetic Things,” he presented a new model of computation: smart technologies that have been developed to help people take care of their physical health through the collection and quantification of their own data. Examples of these tools are fitness trackers in smart watches, Google’s AR Device Glass, and Vitality’s GlowCaps. All of these tools are built to be more empathically responsive, human-orientated, and thus closer to human bodies, following the trends of “well-being,” “efficiency,” and “work-productivity”—often referred to as “the quantified-self” or “augmented humanity,” as coined by Google CEO Eric Schmidt. These technologies are intended to assist self-improvement and self-cultivation (Moritz, 2016).

In some ways, these technologies remind us of the Tamagotchi era in the 1990s, the main difference being that now the Tamagotchi is the human being itself.¹ It

¹ The Tamagotchi is a hand-sized digital pet, realised through a virtual pet simulation game,

seems we have experienced the opposite: we need to be looked after, to be fed on time, and to lead a healthy life. Some of us made ourselves dependent on digital tools, measuring our pulse, sugar, working time, breaks, and footsteps, tracking down our motion in certain locations, allowing for a detailed evaluation of how good the orientation was and how much improvement is needed to reach destinations more time-efficiently. Everything, so it seems, needs to be more efficient and optimised, including ourselves. This represents a bizarre and stunning evolution of mankind—the use by humans of all the new possibilities of net technology and pervasive, ubiquitous media in order to build an active, dynamic human model of themselves (Mul, 2014).

Here I would like to question why this is happening: Is it because we are afraid of losing track of ourselves? Do we really need to ask our watch to tell us if our day was healthy, rather than just listening to our own bodies? These technologies may be closer to our bodies, yet that closeness is causing an estrangement; a distance in how we feel our own body and its needs. Initially, technological tools were not meant to be prostheses for the human being, but rather to serve as a help or servant to empower humans, bolstering their self-esteem. At times, it

Created in Japan in 1996 and released internationally in 1997. It needed regular care, such as food, or even medicine. Some users developed a strong emotional bond with their digital pets, whilst others frequently let them die and get born again. The Tamagotchi started as an egg, which needed to be watched until a new pet hatched and then started its new life cycle. In the first two releases, the digital pets could already die after half a day without being looked after (Johnson, 2016).

seems that now the exact opposite is taking place, making the human being less self-sufficient.

Perhaps these developments should be seen more as an experiment; a work in progress of novel forms and formats of our own subjectivity, translations of our bodies, moods, and behaviour into traceable data, ready to be reshaped (Moritz, 2016)? However, this modelling of personal data can also be seen as empowering and seems to correspond exactly to the general (and growing) need for self-representation in virtual online worlds, as conditioned by Facebook and the era of the selfie.

Appendix II: Creative and Performing Work

Publications:

_Beyer, I. (2015), 360°-Darstellungskonzepte im Wandel der Zeit (360°-representational concepts in transition of time) Institute for Immersive Media (ED) Jahrbuch immersiver Medien, Die mediatisierte Gesellschaft: Leben und Arbeiten mit immersiven Medien, Coburg: Schüren, pp. 53–62.

_Beyer, I. (2014). Le Passage: An archaeology of spatial transitions. *Ubiquity: The Journal of Pervasive Media*, 3 (1), pp. 51–65. doi: 10.1386/ubiq.3.1-2.51_1.

_Buczek, I. (2013) 'Visualization Processes of the Invisible in Scientific Practice', Fullspace-Projektion: Mit dem 360°lab zum Holodeck (X.media.press), Springer-Verlag, Berlin Heidelberg.

_Buczek, I. (2011), 'The aesthetic of immersion in the immersive dome environment (IDE): Stepping between the real and the virtual worlds for further self-constitution?', *Technoetic Arts: A Journal of Speculative Research* 9: 2+3, pp. 327–334, doi: 10.1386/tear.10.1.3_1

_Buczek, I. (2012), 'Augen im All – Das Making Of einer multimedialen Planetariumsshow als Pionierarbeit und Pilotprojekt in der europäischen 360° Filmproduktionsgeschichte'. FULLSPACE-PROJEKTION- MIT DEM 360°LAB ZUM HOLODECK, Springer Verlag

_Buczek, I. (März 2011) 'Everything is possible: „The making of Touching the Edge of the Universe“ in Planetarian (magazine)

_Buczek, I. (2010), „Making of | ESA Planetarium“. Article in Digital Production (magazine)

Presentation:

_Beyer, I. (2015), „The 360°-Creation Process in the Transition of Time“, presentation at i-DAT, Plymouth University, UK

_Beyer, I. (2015), „The Zoom Transition“ presentation at the Imersa Conference, Denver Planetarium, Denver, USA

_Buczek, I. (2013), “The Art of Understanding in the Mirror of new Visualization Technologies”. Presentation at COST Arts & Technologies (CAT) Workshop, European Science Foundation, 25 - 27 November 2013, Zagreb, Croatia

_Buczek, I. (2013), “ The Explanatory Power of Models with Today’s Visualization Capabilities”. Paper presented at International Conference on Extended Arts (XARTS 2013), From Virtual to Real, 20-21 July, 2013, University of the Aegean, Greece

_Buczek, I. (2012), “Aesthetic of Immersion in the immersive dome environment (IDE), paper presented at Technoetic Telos: Art, Myth and Media Conference at the Ionian Centre for Arts and Culture, Kefalonia, Greece.

Buczek, I. (2012). What happens with spatial purity in the media revolution of materiality and hybridization? Paper presented at the Conference MutaMorphosis at the Czech Academy of Sciences, Prague, Czech Republic.

_Buczek, I. (2011), "Transmedial Intersections of media platforms in the 360°medium" paper and presentation delivered at the Transcultural Tendencies |Transmedial Transactions Conference, Shanghai Institute of Visual Studies, Fudan University (SIVA), Shanghai, China.

_Buczek, I. (2011), "Visualization Processes of the Invisible in Scientific Practice - Virtually Simulated Epistemic Structures in 360° Space", presentation at the Presence in the Mindfield, Conference at Centro Cultural de Belém Praça do Império Lisbon, Portugal.

_Buczek, I. (2011), 'The immersive dome environment (IDE): Old concept in a new light or a new hybrid medium to enhance human cognitive faculty?' Paper presented at the TTTT Media Arts Conference at the Shanghai Institute of Visual Art, Fudan University (SIVA), Shanghai

Further presentations on invitations

_Buczek, I. (2013), "Science Communication – Why in the Dome?". Presentation delivered at ECSITE (European Network of Science Centers and Museums) Conference, 07.06.2013, Gothenburg, Sweden

_Buczek, I. (2011), "The impact of immersion in science communication".

Presentation delivered at ECSITE (European Network of Science Centers and Museums) Conference, 28.05.2011, Warsaw, Poland.

_Buczek, I. (2011), "In search of a 360° visual language". Presentation delivered at Fulldome Fest in Jena, May 2011.

_Buczek, I. (2011), "Real-Time Systems on the Planetarium Market - Chances and Challenges". Presentation delivered at Fulldome Fest in Jena, May 2011.

_Buczek, I. (2011), "Paradigms of the visual speech – emotional and spatial concepts for the 360° projection medium". Presentation delivered at Fraunhofer-First, Berlin.

Filmography (Own Creative Work):

„Die drei ??? und der dreiäugige Totenkopf“ (The three investigators and the Three-Eyed Death's Head). Art direction and design of 21 360° scenes for the company Northdocks and Sony Music Entertainment Germany GmbH. Germany | 2018

„Superhelden der Ozeane“ (Superheroes of the Deep Sea). Transmedia concept and several productions for Fulldome, VR, AR, 3D prints and an online presentation, awarded with a grant from the German Federal Ministry of Education and Research (BMBF), Wissenschaftsjahr 2016*17. Germany | 2017

„360° VR Experience. Wind turbine.“ 360°film based on drone-fish-eye-VR-recording with Northdocks for Energie Baden-Württemberg AG (EnBW). Germany | 2017

„Wasserflüsse in Deutschland“ (Water rivers in Germany) production of four HD-films for the Institut für ökologische Wirtschaftsforschung (IÖW) and the German Federal Ministry of Education and Research (BMBF). Germany | 2014

„Integriertes Wasserressourcen-Management (IWRM) für China, Indonesien, Israel-Jordanien-Palästina, Mongolei, Namibia, Südafrika und Vietnam“ (integrated water resources management). Production of five fulldome-films für Helmholtz-Zentrum für Umweltforschung GmbH (UFZ) (Helmholtz Centre for Environmental Research). Germany | 2013

„Dream to Fly“, complementary production of two scenes and consultation for the Copernicus Science Center Warsaw, Poland | 2013 (the film won several awards in the fulldome industry)

„Touching the Edge of the Universe“, own Production at the University of Applied Sciences Kiel for the European Space Agency (ESA) and a consortium of 30 German speaking Planetariums, Germany | 2009

„Unser Kosmos - Heimat der Menschen“, (Our Cosmos - Home to Humankind) 3D animation for Mediendom at the University of Applied Sciences Kiel - Kiel, Germany | 2008

„The Descent. An Expedition into the Deep Sea“ own production for Geomar and the Mediendom (Kiel Planetarium) at the University of Applied Sciences Kiel, Germany | 2007

„Sind wir allein“, (The Search for Life: Are We Alone), a complementary production for the life presentation at the end of this show - Hamburg, Germany | 2007

„Die Himmelsscheibe von Nebra“, (The Skydisc of Nebra), a full production of a 20 minutes show for the Science Center, Arche Nebra and Landesamt für Denkmalpflege und Archäologie Sachsen-Anhalt - Landesmuseum für Vorgeschichte, together with the Planetarium Hamburg. Germany | 2007

“Deep Space Night 3.0”, a late-night music show presenting 50 years of space flight history, a fulldome production together with the Planetarium Hamburg, Germany | 2007

“Meine Heimat - unser blauer Planet”, (My Homeland - Our Blue Planet), a show production for children together with the Planetarium Hamburg, Germany | 2007

“Die Zukunft ist wild”, (“The Future is Wild”), a show on a possible future in 5 million years based on plate tectonics produced with the Planetarium Hamburg. Germany | 2006

“The Problem with Pluto”, 360° production together with the Melbourne Planetarium. Australia | 2006

„Lightning. Inside the Phenomenon“, a stereoscopic production for the V-Room at the Melbourne Museum. Australia | 2005

“Life Rhythm”, exhibited at the Monash University Multimedia Centre, artistic music video, Melbourne. Australia | 2005

„DVB- T“ Corporate film for the Karstadt company, played in den Filialen Kiel, Hamburg, Düsseldorf und Frankfurt. - Germany | 2005

“VIP”, 360° production for the Band Fury in the Slaughterhouse and the opening event in the Hamburg and Kiel Planetarium, concept, storyboard, drawings, 3D modelling. Germany | 2004

“Sport Bottle”, exhibited in the Ministergärten Berlin at the “Common Ground” exhibition, package design, 3D modelling, print Kiel. Germany | 2004

Appendix III: Creative Work

A. Whole PhD thesis as PDF (on the flash drive)

B. Selection of the 360° Creative Work (on the flash drive)

01_The Three Investigators (Germany, 2018):

01. 21 final 360° image scenes

02_Superheroes of the Deep Sea (Germany, 2017):

01. Film of the event "Superhelden_VRTauchstation_KiWo.mp4"

02. The 360° film for the dome "Superheros_Schnitt_Fulldome_v004.mp4" (fulldome format)

03_VR Experience. Wind turbine. (Germany, 2017):

01. 360° drone film of the outside passage: "01_Outside_20170426_v001_360.mp4" (equirectangular format)

02. 360° drone film of the inside passage: "02_Inside_20170426_v001_360.mp4" (equirectangular format)

04_360° Unfolding_Paper_Landscape (Germany, 2014)

01. 360° movie sample "paper_landscape_25_1.mov" (fulldome format)

05_integrated water resources management (IWRM) für China, Indonesien, Israel-

Jordanien-Palästina, Mongolei, Namibia, Südafrika und Vietnam (Germany, 2013):

01. 360° film Cuve Waters on Namibia "Cuve_Waters_eng.wmv" (fulldome format)

06_Dream to Fly. (Poland, 2013):

01. The 360° film preview "DTF_ENG_1k iPad.mp4" (fulldome format)

My scenes: 02:26 – 03:21

07_Touching the Edge of the Universe. (Germany, 2009)

01. The 360° film preview "augen_im_all_evaluation-copy.wmv" (fulldome format)
02. One image of the Galileo scene

08_The Descent. An Expedition into the Deep Sea (Germany, 2007)

01. 360° images of the production

09_Urban Vision (Germany, 2007)

01. The 360° film preview "Urbane Vision.mp4" (fulldome format)
02. 360° images

10_The Skydisc of Nebra (Germany, 2007)

01. 360° images of the production

11_VIP (Germany, 2004)

01. 360° images of the production
02. 360° movie preview "VIP_Preview.mp4" (fulldome format)